Final Report

Bio-economic Modeling for Oil Spills from Tanker/Freighter Groundings on Rock Pinnacles in San Francisco Bay

Volume III of VII
Spill Response Report – Shag Rock

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Note on Cost Data Valuations

All cost data have been estimated based on 2001 dollars. Costs have been rounded to the nearest thousand in summary tables. Projections as to future costs can be made using the following table (Table A):

Table A

Future Dollar Valuation (from 2001 $)	
Year	**Conversion Factor**
2001	1.000
2002	1.025
2003	1.052
2004	1.078
2005	1.106
2006	1.134
2007	1.165
2008	1.192
2009	1.224
2010	1.254
Adapted from Robert Sahr, Political Science Dept., Oregon State University, Corvallis, Oregon	

Future costs can be projected by multiplying the calculated 2001 dollar values by the listed conversion factors for the appropriate future year. (This is done for the total response cost estimates and total per-gallon response cost estimates in Section 8.0).

Regional adjustments (for California) have been made to all of the appropriate cost figures appearing in this report (as 2001 dollars). The future cost conversion figures assume that the relative regional differences in Consumer Price Indices remain the same as they are at the beginning of 2002. Any known or anticipated changes in future regional differences can be factored in as need in the future. For more information on regional cost adjustments, see Appendix A.

Executive Summary

Oil spill response costs depend greatly on the location of the spill (proximity to sensitive shoreline resources, difficulty of cleaning up types of environments impacted, local socioeconomic values, local regulations), the type of oil spilled (toxicity and persistence characters), the amount of oil spilled, and the response strategies employed. Response cost estimations for twelve oil spill scenarios (four oil types X 3 spill sizes per oil type) were estimated based on oil spill modeling performed by French McCay et al. (2002) using Applied Science Associates' model SIMAP. The SIMAP modeling results provided information on the spread of the surface oil and shoreline oiling in terms of area and location of coverage for each of six shoreline types – mudflat, wetland, sandy beach, rocky beach, gravel beach, and artificial shoreline.

The modeling runs for each of the twelve scenarios were analyzed to determine the median (50^{th} percentile) outcome and "worst" (95^{th} percentile) outcome. For the lighter fuel spills (diesel and gasoline), the median and worst outcomes were defined as the 50^{th} and 95^{th} percentiles of water column damage. While this would not necessarily result in the highest response costs, these model runs would result in the median and worst natural resource damages related to water column injuries. For the heavier oil spills (heavy fuel oil and crude oil), the median and worst outcomes were defined as the 50^{th} and 95^{th} percentile of shoreline costs as determined by cost-weighted shoreline type impacts. For the heavier oil scenarios, the cleanup response costs would tend to predominate the total cost picture and natural resource damages would be relatively lower.

Response costs were determined based on two different on-water response strategies – (1) traditional mechanical containment and recovery, and (2) dispersant application. While responses to most US spills have entailed the use of mechanical containment and recovery methodology, risk assessment studies on San Francisco Bay and changes within state and national policy on the use of dispersants indicate that dispersants will likely become a first-order response option for this region within the next few years. Any comprehensive analysis of response costs and cost projections for the next decade should properly involve an examination of dispersant costs in addition to mechanical recovery costs. In the future some spill responses will likely employ a combination of response strategies. The cost projections for a combined response strategy can be proportionately extrapolated from the costs for the different strategies. For dispersant application, two types of scenarios were modeled based on assumptions of higher and lower dispersant effectiveness, since the actual field effectiveness of the dispersant applications would have a significant impact on the cost calculations.

All cost calculations were based on known regional-specific equipment and labor costs and information from previous oil spill case histories. Total response costs were determined by adding the on-water response costs (mechanical recovery, higher-effective dispersant application, or lower-effective dispersant application) to shoreline response operation costs. Additional costs that would be expected in a response operation, including those costs for mobilization, salvage and lightering (for source control), and spill management and monitoring, were also included. All costs were calculated based on a government-run response operation based on government rates. *Costs to a private responsible party (vessel owner/operator) can run higher than the cost estimates presented in this analysis. Response contractors often charge private parties higher rates than allowed in government transactions. In addition, costs can run higher (as much as 2-3 times) in cases where there are additional mitigating circumstances or where serious errors or omissions are made during the course of the response.*

Table i: Estimated Total Response Costs For Oil Spills In San Francisco Bay

Scenario		**Spill Outcome[1]**	**Primary On-Water Response Strategy**		
Oil Type	**Percentile Gallons**		**Mechanical**	**Dispersant[2]** ***Low Effectiveness***	**Dispersant[3]** ***High Effectiveness***
Diesel	**20th (50,000)**	Median	$12,205,500	$10,453,000	$9,608,000
		Worst	$14,385,500	$11,761,000	$10,044,000
	50th (270,000)	Median	$18,788,500	$14,113,000	$11,122,000
		Worst	$13,078,500	$10,687,000	$9,980,000
	95th (1,250,000)	Median	$26,894,500	$19,492,000	$14,539,000
		Worst	$31,664,500	$22,354,000	$15,493,000
Gasoline	**20th (50,000)**	Median	$10,021,000	$9,194,000	$9,183,000
		Worst	$10,007,000	$9,185,000	$9,180,000
	50th (270,000)	Median	$11,044,000	$9,681,000	$9,600,000
		Worst	$11,010,000	$9,661,000	$9,593,000
	95th (1,250,000)	Median	$13,402,000	$11,645,000	$11,427,000
		Worst	$15,025,000	$12,619,000	$11,752,000
Heavy Fuel Oil	**20th (25,000)**	Median	$11,619,000	$7,708,000	$6,395,000
		Worst	$13,919,000	$9,203,000	$7,085,000
	50th (100,000)	Median	$35,107,000	$20,187,000	$12,385,000
		Worst	$50,537,000	$30,216,000	$17,014,000
	95th (410,000)	Median	$78,087,000	$41,224,000	$22,544,000
		Worst	$122,207,000	$69,902,000	$35,780,000
Crude	**20th (100,000)**	Median	$29,549,000	$18,490,000	$14,606,000
		Worst	$36,029,000	$22,378,000	$15,902,000
	50th (600,000)	Median	$65,498,000	$31,352,000	$19,804,000
		Worst	$83,698,000	$42,272,000	$23,444,000
	95th (3,000,000)	Median	$182,144,000	$71,345,000	$37,697,000
		Worst	$230,184,000	$100,169,000	$47,305,000

[1]Shoreline costs for median/worst water column-impacted runs for diesel and gasoline and median/worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.
[2]Assumes 35% effectiveness for HFO and 40% effectiveness for other oils.
[3]Assumes 70% effectiveness for HFO and 80% effectiveness for other oils.

Cost projections for future years (through 2010), both in terms of total response costs and per-gallon response costs, were made for all response strategies. Total response costs and per- gallon costs (in 2001 dollars) for the twelve oil spill scenarios are shown in the following tables.

Table ii: Estimated Total Per-Gallon Response Costs For Oil Spills In San Francisco Bay					
Scenario		**Spill Outcome[1]**	**Primary On-Water Response Strategy**		
Oil Type	**Percentile Gallons**		**Mechanical**	**Dispersant[2]** ***Low Effectiveness***	**Dispersant[3]** ***High Effectiveness***
Diesel	**20th (50,000)**	Median	$244	$209	$192
		Worst	$288	$235	$201
	50th (270,000)	Median	$70	$52	$41
		Worst	$48	$40	$37
	95th (1,250,000)	Median	$22	$16	$12
		Worst	$25	$18	$12
Gasoline	**20th (50,000)**	Median	$200	$184	$184
		Worst	$200	$184	$184
	50th (270,000)	Median	$41	$36	$36
		Worst	$41	$36	$36
	95th (1,250,000)	Median	$11	$9	$9
		Worst	$12	$10	$9
Heavy Fuel Oil	**20th (25,000)**	Median	$465	$308	$256
		Worst	$557	$368	$283
	50th (100,000)	Median	$351	$202	$124
		Worst	$505	$302	$170
	95th (410,000)	Median	$190	$101	$55
		Worst	$298	$170	$87
Crude	**20th (100,000)**	Median	$295	$185	$146
		Worst	$360	$224	$159
	50th (600,000)	Median	$109	$52	$33
		Worst	$139	$70	$39
	95th (3,000,000)	Median	$61	$24	$13
		Worst	$77	$33	$16

[1]Shoreline costs for median/worst water column-impacted runs for diesel and gasoline and median/worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.
[2]Assumes 35% effectiveness for HFO and 40% effectiveness for other oils.
[3]Assumes 70% effectiveness for HFO and 80% effectiveness for other oils.

In the future it is very likely that there will be increasing reliance on chemical dispersants as a primary response tool, though there will be some situations in which this technique is undesirable, ineffective or impractical. In addition, there will be situations in which mechanical recovery is relied on to a small extent. Since there is a great difference in the costs associated with these response techniques, a methodology for weighting the most probable response techniques in future spills is presented as shown in the following table.

Table iii: Relative Weighting Of Mechanical And Dispersant Application Efforts For Typical Post-2004 Spill Responses[1,2]						
Volume (gallons)	**Year**					
	2005	**2006**	**2007**	**2008**	**2009**	**2010**
<100,000	$0.8D_l + 0.2M$	$0.85D_l + 0.15M$	$0.9D_l + 0.1M$	$0.9D_h + 0.1M$	$0.95D_h + 0.05M$	$0.99D_h + 0.01M$
100,000 – 500,000	$0.7D_l + 0.3M$	$0.75D_l + 0.25M$	$0.8D_l + 0.2M$	$0.8D_h + 0.2M$	$0.85D_h + 0.15M$	$0.9D_h + 0.1M$
>500,000	$0.6D_l + 0.4M$	$0.7D_l + 0.3M$	$0.75D_l + 0.25M$	$0.75D_h + 0.25M$	$0.8D_h + 0.2M$	$0.85D_h + 0.15M$
[1]D_l = low-effectiveness dispersant application effort; D_h = high-effectiveness dispersant application effort; M = mechanical containment and recovery effort [2]The equations presented refer to the weighting of the relative *effort* from each of the response strategies.						

The response costs presented in the analysis assume that the response operations are carried out according to the Area Contingency Plan (US. Coast Guard 2001) and that reasonable costs are associated with these operations. The modeling assumes that mechanical recovery will have negligible effectiveness and that all oil will reach the shoreline. In order to estimate the maximum expected costs associated with response to simulate situations in which all on-water response measures are ineffective and there is an excess or redundancy of equipment and personnel due to misjudgment or other reasons, cost estimates were maximized as appropriate for the San Francisco Bay based on historical cases with extraordinary costs.

Full distributions of costs based on 100 runs to determine shoreline oiling were created to find the 99th percentile (absolute worst case (maximum) of the model runs) shoreline oiling and associated on-water response costs. These worst case values were then further maximized by applying the complete ineffectiveness and excess mobilization criteria as described above. These maximized values were weighted according to the table above to calculate most-probable *maximum* response costs as shown in the following tables. The costs are adjusted for future values.

Table iv: Total Estimated MAXIMUM Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2001 - 2005						
Scenario		**Total Projected Response Costs[2]**				
Oil	**Percentile**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	$20,812,999	$21,333,324	$21,895,275	$22,436,413	$23,094,385
	50th	$55,028,194	$57,028,194	$58,530,400	$59,976,969	$61,903,332
	95th	$61,973,419	$63,522,755	$65,196,037	$66,807,346	$70,242,745
Gasoline	**20th**	$14,090,101	$14,442,354	$14,822,786	$15,189,129	$15,665,938
	50th	$16,077,109	$16,479,036	$16,913,118	$17,331,123	$18,128,898
	95th	$21,457,913	$21,994,361	$22,573,725	$23,131,631	$25,055,007
Heavy Fuel Oil	**20th**	$21,013,096	$21,538,423	$22,105,777	$22,652,117	$23,302,420
	50th	$86,682,546	$88,849,609	$91,190,038	$93,443,784	$96,024,187
	95th	$188,793,248	$193,513,079	$198,610,497	$203,519,121	$209,294,627
Crude	**20th**	$56,141,232	$57,544,763	$59,060,576	$60,520,248	$62,219,171
	50th	$132,302,912	$135,610,485	$139,182,663	$142,622,539	$147,010,529
	95th	$358,574,630	$367,538,996	$377,220,511	$386,543,452	$399,817,264

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table v: Total Estimated MAXIMUM Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2006 - 2010						
Scenario		**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	$23,683,873	$24,336,267	$24,900,283	$25,573,949	$26,205,025
	50th	$63,497,494	$65,261,043	$66,773,531	$68,595,240	$70,306,341
	95th	$72,311,573	$74,437,581	$76,162,744	$78,364,176	$80,445,503
Gasoline	**20th**	$16,067,817	$16,512,478	$16,895,171	$17,354,424	$17,784,443
	50th	$18,613,316	$19,148,300	$19,592,080	$20,145,521	$20,667,436
	95th	$25,915,317	$26,739,853	$27,359,575	$28,216,032	$29,032,562
Heavy Fuel Oil	**20th**	$23,896,323	$24,553,651	$25,122,706	$25,801,425	$26,437,324
	50th	$98,466,406	$101,169,702	$103,514,407	$106,305,435	$108,923,375
	95th	$214,629,059	$220,533,158	$225,644,227	$231,740,468	$237,460,008
Crude	**20th**	$63,803,639	$65,557,383	$67,076,739	$68,887,494	$70,586,195
	50th	$150,849,116	$155,032,855	$158,625,891	$162,947,340	$167,005,729
	95th	$410,491,818	$421,997,228	$431,777,421	$443,666,989	$454,846,717

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table vi: Total Estimated MAXIMUM Per-Gallon Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2001 - 2005						
Scenario		**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	$416	$427	$438	$449	$462
	50th	$206	$211	$217	$222	$229
	95th	$50	$51	$52	$53	$56
Gasoline	**20th**	$282	$289	$296	$304	$313
	50th	$60	$61	$63	$64	$67
	95th	$17	$18	$18	$19	$20
Heavy Fuel Oil	**20th**	$841	$862	$884	$906	$932
	50th	$867	$888	$912	$934	$960
	95th	$460	$472	$484	$496	$510
Crude	**20th**	$561	$575	$591	$605	$622
	50th	$221	$226	$232	$238	$245
	95th	$120	$123	$126	$129	$133

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table vii: Total Estimated MAXIMUM Per-Gallon Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2006 - 2010						
Scenario		**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	$474	$487	$498	$511	$524
	50th	$235	$242	$247	$254	$260
	95th	$58	$60	$61	$63	$64
Gasoline	**20th**	$321	$330	$338	$347	$356
	50th	$69	$71	$73	$75	$77
	95th	$21	$21	$22	$23	$23
Heavy Fuel Oil	**20th**	$956	$982	$1,005	$1,032	$1,057
	50th	$985	$1,012	$1,035	$1,063	$1,089
	95th	$523	$538	$550	$565	$579
Crude	**20th**	$638	$656	$671	$689	$706
	50th	$251	$258	$264	$272	$278
	95th	$137	$141	$144	$148	$152

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

1.0 Oil Spill Cleanup Cost Estimation Based on Simple Per-Unit Costing

The most obvious approach to projecting cleanup response costs for the San Francisco Bay oil spill scenarios might be to estimate the per-gallon costs based on data from past spills. The derived per-gallon cleanup cost figure could then simply be multiplied by the spill volume for each scenario to obtain total response costs.

The use of an *overall* cost per-gallon does not, however, reflect the tremendous variation in factors that influence cleanup costs in each spill. While there are certainly circumstances particular to each spill making each spill a unique event in terms of response and resultant costs, a few generalized trends were noted in previous studies on historical spill data by Etkin (1998*a*, 1998*b*, 1999*a*, 2000, 2001*a*):

1. Per-unit costs were higher for spills involving *more persistent oils*;
2. Per-unit costs were highest for responses relying on *mechanical and manual methods* rather than on dispersant application;
3. Per-unit costs were higher for *smaller* spills;
4. Per-unit costs were higher for *nearshore/port* spills than for offshore spills;
5. Per-unit costs were higher for spills involving *extensive shoreline oiling*;
6. Per-unit costs were higher in regions with high "how clean is clean" standards for shoreline oil removal due to local values and existence of coastal areas with high natural resource and/or socioeconomic values; and
7. Per-unit costs were higher for spills involving *extensive oiling of mudflat and wetland shoreline areas*.

Based on an analysis of known cleanup costs and various factors for over 200 oil spill scenarios, an average cost of $90 per gallon (in 2001 dollars) spilled was derived for US oil spills (Etkin 2000*a;* 2001*a*). While this $90/gallon figure could be adjusted to reflect different scenario-specific factors based on algorithms and cost modifying constants (as in Etkin 2000*a;* 2001*a*), the resulting estimates would still be too generalized for the current study.

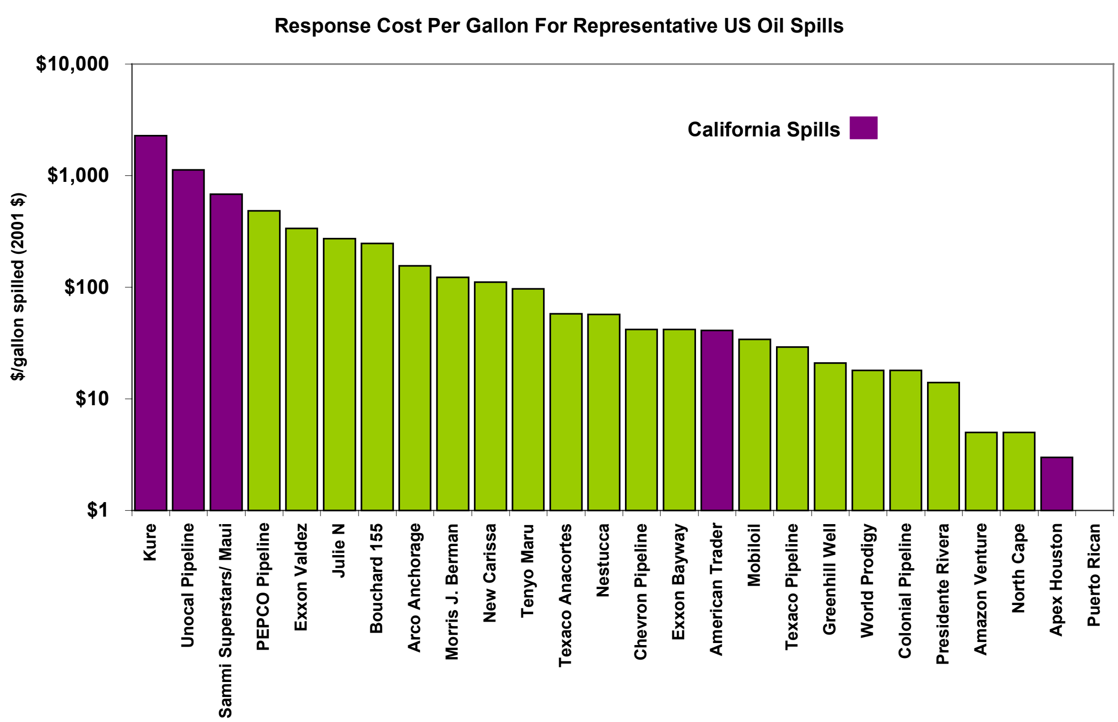
The averaged results would tend to *underestimate* response costs by not adequately factoring in local concerns with respect to stringent standards of shoreline cleanliness due to both local values and the existence of valuable coastal resources. In addition, these results would ignore the recent national trend toward increasingly inflated response costs. An increased tendency to mobilize large amounts of equipment and personnel to be on "standby," as well as an increased vigilance in cleanup standards (perhaps to avoid more costly restoration and damage assessments) has resulted in an escalation of costs.

It should be noted that the M/V *Kure* spill in Humboldt Bay, California, often cited as the "most expensive spill on a per-gallon basis in US history" was particularly expensive due to the large amount of equipment and personnel mobilized for a potentially large spill that would impact bird sanctuaries. The spill did not reach the potential size initially predicted. Large-scale mobilization of equipment and personnel can lead to exceptionally high costs in relation to the actual oil eventually spilled and is ensuing damages. These factors must be taken into consideration, however, when planning for hypothetical spill scenarios.

The response to the 2000 PEPCO pipeline spill of 126,000 gallons of a combination of No. 6 and No. 2 fuel oils, was extremely expensive in relation to analogous spills. The wetland impact necessitated a careful, labor-intensive response. Spills impacting wetlands also tend to generate large amounts of oily debris/waste, particularly when No. 6 fuel is involved. The disposal of oily waste can constitute a significant cost category. In the PEPCO case there were also a number of key errors that were made early in the response along with unfortunate circumstances, including an ill-timed storm, that contributed to considerable spreading of the oil with resultant wetland impact.

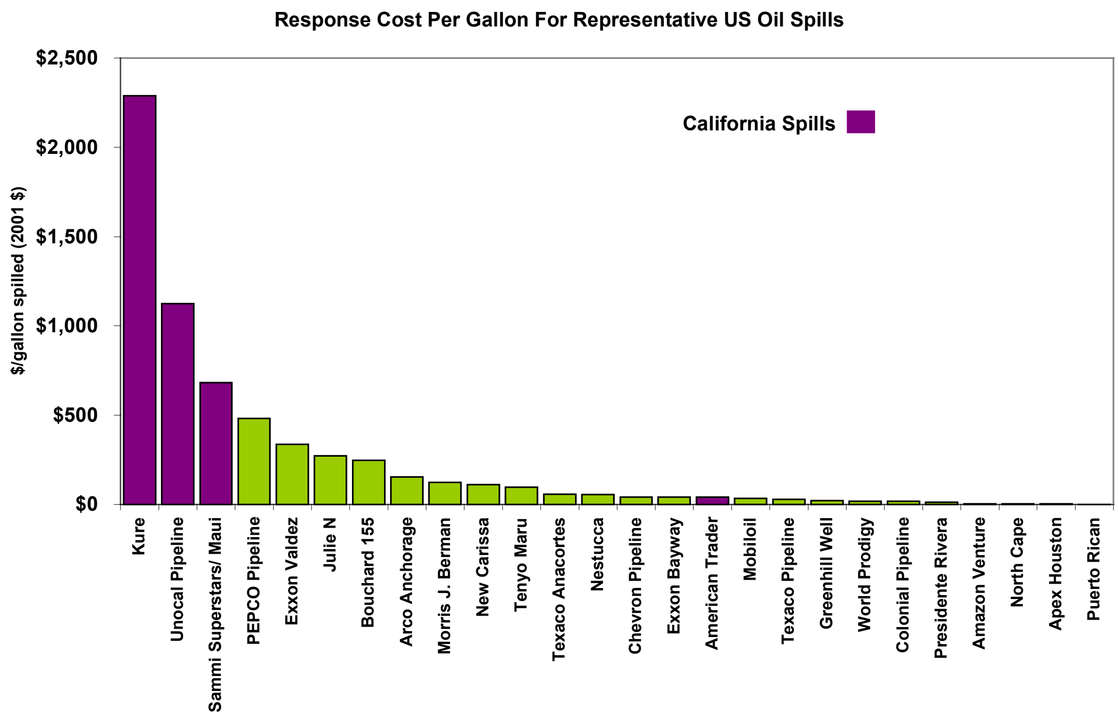
A synopsis of spill response costs (updated to 2001 dollars) for representative US oil spills is shown in Figure 1 (note logarithmic scale) and Figure 1a (with normal scale) and Table 1.

Figure 1



California spills can be found in the most-expensive as well as least expensive categories. The differences between these spills depends highly on location of the spill in terms of its proximity to sensitive resources, including natural resources (such as bird nesting sites and wetlands), as well as socioeconomic resources (such as marinas and tourist beaches).

Figure 1a



The Unocal pipeline spill at Avila Beach, California, and the MV *Sammi Superstars*/MV *Maui* spill (which ultimately involved two vessels) at Long Beach, California, involved areas with sensitive socioeconomic and natural resource areas. Note also that the two *least* expensive spills (even when normalized to 2001 dollars) – the 1986 T/B *Apex Houston* and the 1984 T/V *Puerto Rican* – occurred before the T/V *Exxon Valdez* spill, an incident seen by many as a turning point in national and state oil spill legislation – with resultant increases in spiller liability, cleanliness standards, and costs.

Table 1

Per-Gallon Oil Spill Response Costs For Representative US Oil Spills *(California spills are in bold)*				
Spill Source	**Location/Impact Type**	**Oil Type**	**Spill Size (gallons)**	**Per-Gallon Cleanup Costs (2001 $)**
M/V Kure (1997)	**Humboldt Bay, CA (high potential bird impact)**	**IFO**	**4,500**	**$2,289**
Unocal Pipeline (1992)	**Avila Beach, CA (marina/sandy beach impact)**	**crude**	**14,700**	**$1,125**
M/V Sammi Superstars M/V Maui (1991)	**Long Beach, CA (marina impact)**	**No. 6 fuel**	**32,000**	**$682**
PEPCO Pipeline (2000)	Patuxent R., Chalk Point, MD (marsh impact)	No. 6 fuel	126,000	$482
T/V Exxon Valdez (1989)	Prince William Sound, AK (rocky shoreline impact)	crude	11,000,000	$337
T/V Julie N (1996)	Fore R., Portland, ME (marsh impact)	No. 6 fuel	180,000	$273
T/B Bouchard 155 (1993)	Tampa Bay, FL (marsh/mangrove impact)	No. 6 fuel	333,000	$248
T/V Arco Anchorage (1985)	Port Angeles, WA (moderate shoreline impact)	crude	189,000	$155
T/B Morris J. Berman (1994)	Caribbean Sea, San Juan, PR (sandy beach impact)	No. 6 fuel	789,000	$123
M/V New Carissa (1999)	Pacific Ocean, Coos Bay, OR (sandy shoreline impact)	No. 2, 4 fuels	70,000	$111
F/V Tenyo Maru (1991)	Neah Bay, WA (sandy/rocky shoreline impact)	No. 2, 4 fuels	173,000	$97
Texaco Anacortes Refinery (1991)	Puget Sound, Anacortes, WA (marsh impact)	crude	210,000	$58
T/B Nestucca (1988)	Pacific Ocean, Aberdeen, WA (rocky/sandy shoreline impact)	No. 6 fuel	253,000	$57
Chevron Pipeline (1996)	Pearl Harbor, Oahu, HI (marsh impact)	No. 6 fuel	41,200	$42
Exxon Bayway Pipeline (1990)	Arthur Kill, New York, NY (marsh impact)	No. 2 fuel	567,000	$42
T/V American Trader (1990)	**Huntington Beach, CA (sandy/rocky shoreline impact)**	**crude**	**417,000**	**$41**
T/V Mobiloil (1984)	Columbia R., St. Helens, OR (sandy/rock shoreline impact)	No. 6 fuel	169,000	$34

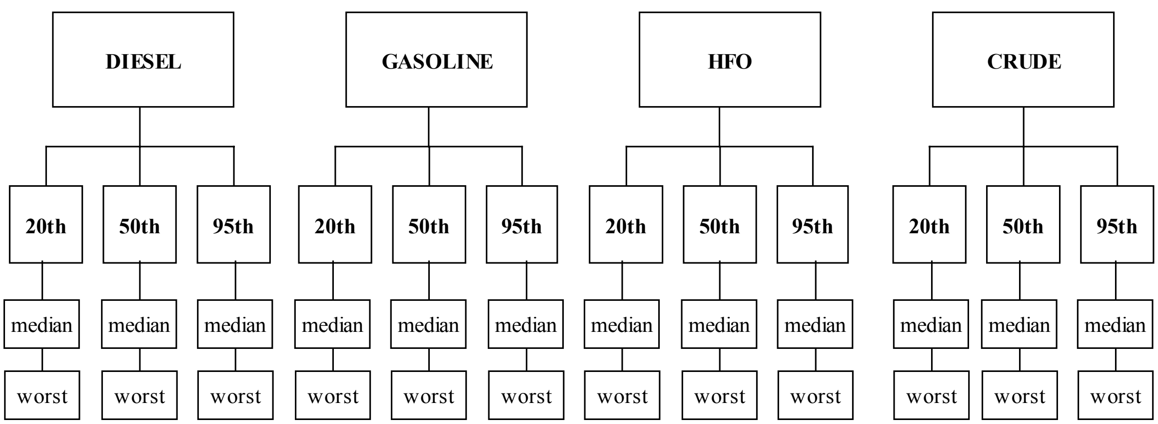
Table 1 (continued)

Per-Gallon Oil Spill Response Costs For Representative US Oil Spills *(California spills are shaded)* (cont.)				
Spill Source	**Location/Impact Type**	**Oil Type**	**Spill Size (gallons)**	**Per-Gallon Cleanup Costs (2001 $)**
Texaco Pipeline (1997)	Lake Barre, Cocodrie, LA (marsh impact)	crude	276,000	$29
Greenhill Well Blowout (1992)	Gulf of Mexico, Timbalier Bay, LA (marsh impact)	crude	96,600	$21
T/V World Prodigy (1989)	Newport, RI (rocky shoreline impact)	No. 2 fuel	294,000	$18
Colonial Pipeline (1993)	Reston, VA (river impact)	No. 2 fuel	407,000	$18
T/V Presidente Rivera (1989)	Delaware R., Marcus Hook, PA (marsh impact)	No. 6 fuel	300,000	$14
T/V Amazon Venture (1986)	Savannah R., Savannah, GA (marsh impact)	No. 6 fuel	543,000	$5
T/B North Cape (1996)	Block Island Sound, Galilee, RI (marsh impact)	No. 2 fuel	828,000	$5
T/B Apex Houston (1986)	**Gulf of Farallones San Francisco, CA (sandy/rocky beach impact)**	**crude**	**25,000**	**$3**
T/V Puerto Rican (1984)	**Bodega Bay, CA (beach impact)**	**No. 6 fuel**	**2,016,000**	**$1**
Source: Environmental Research Consulting Spill Cost Databases				

2.0 Basic Response Cost Analysis Methodology

Because cleanup costs can vary so much based on the extent and type of shoreline impact, cost analyses were conducted to specifically examine the potential costs of the San Francisco Bay oil spill scenarios based on the potential spread of the oil and location-specific shoreline impacts as modeled stochastically by French McCay et al. (2002) using SIMAP.

The costs for the median (50^{th} percentile) and worst (95^{th} percentile) spill outcomes for each spill scenario (oil type and spill volume) were estimated in the response cost analysis. The 95^{th} percentile outcome was selected (by the Corps of Engineers) to represent a highest expected outcome without examining rare events (such as the worst of all the runs) that may not be well sampled from all possible spill dates and times. The median and worst outcome spills for the light fuels (diesel and gasoline) were selected based on the SIMAP runs that resulted in the 50^{th} percentile and 95^{th} percentile *water column damage* as indicated by the average dose of polycyclic aromatic hydrocarbons (PAHs) in terms of ppb-hours of exposure. The median and worst outcome spills for the heavier oils (heavy fuel oil or "HFO", and crude) were selected based on the SIMAP runs that resulted in the 50^{th} percentile and 95^{th} percentile *shoreline cleanup costs* as determined by shoreline-type weighted cost factors and shoreline area oiled to levels that would require response. (See French McCay, *et al*. 2002, for model scenarios and results.)



Response costs were assumed to include:

- Costs for on-water response operations (either mechanical containment and recovery *or* dispersant application), including personnel, equipment, logistical support, and monitoring;
- Costs for initial mobilization of personnel and equipment;
- Costs for transport and disposal of oil recovered by mechanical containment and recovery;
- Costs for personnel and equipment for shoreline response operations;

- Costs for transport and disposal of oily debris and oil recovered by shoreline response operations;
- Vessel salvage and lightering costs with respect to source control, but *not including* post-incident vessel transport, repair and/or scrapping; and
- Spill management and monitoring by federal authorities (principally US Coast Guard) and/or private entities (responsible party-designated Qualified Individual and spill management team).

Costs were first determined for operations with primary on-water mechanical containment and recovery response and subsequent shoreline response costs. Mechanical containment and recovery (involving the corralling of oil with booms and the recovery of contained oil with skimming devices and vacuum trucks) is the more traditional response strategy and that is currently used in most US spill responses. This on-water strategy has an effectiveness of 15-25% of floating oil under optimal conditions. Oil that is not recovered mechanically is dealt with after it impacts the shoreline.

In the SIMAP modeling, the oil trajectory and shoreline impact does *not* take into account oil removal from on-water mechanical recovery operations. Theoretically, on-water recovery might reduce the amount of stranded oil by as much as 10-20%, though in many cases the reduction would not be this high.

The SIMAP modeling did, however, include *protective* booming at the sensitive locations indicated for protection by the San Francisco Bay Area Contingency Plan (US Coast Guard 2001), as shown in Figure 2 and Table 2.

Figure 2 Protective Booming Locations in San Francisco Bay (see Table 2)

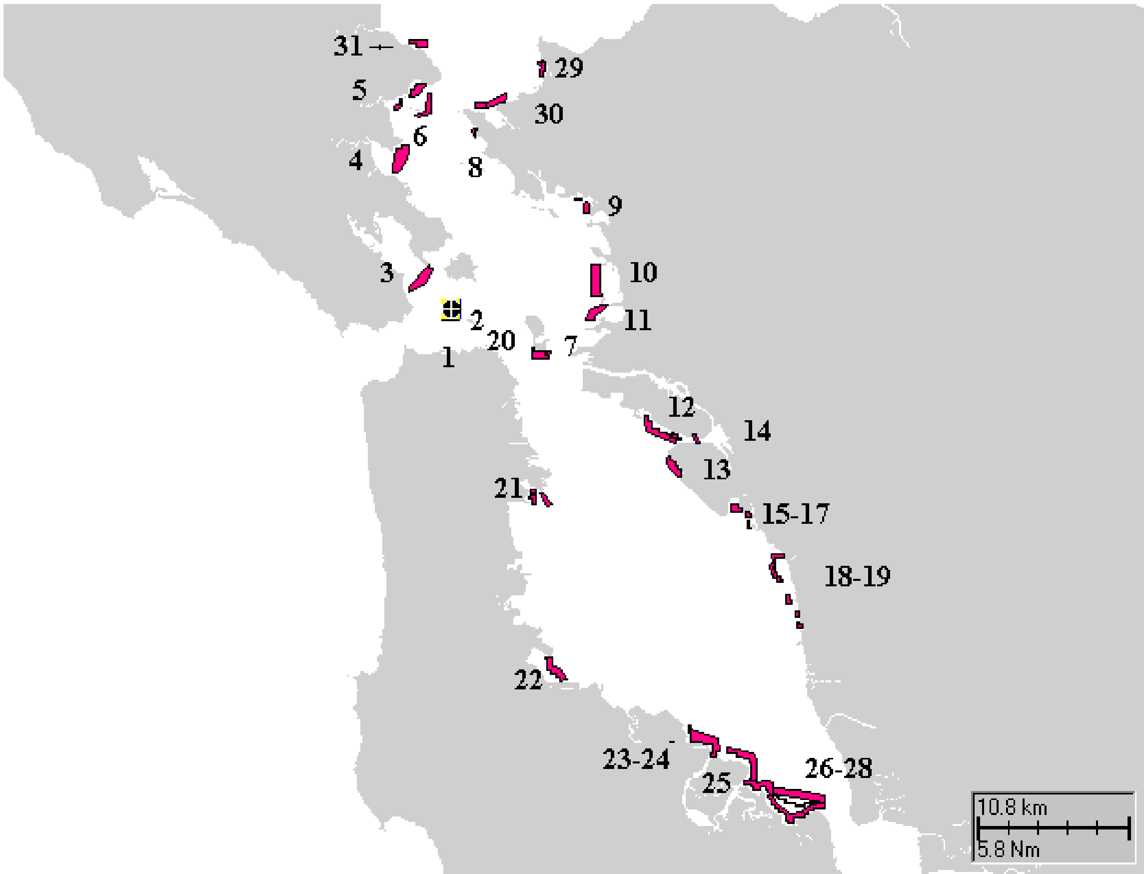


Table 2

San Francisco Bay Area Booming Location Maps				
Site Name	**Site #**	**Lat[1]**	**Lon[1]**	**Map #[2]**
Pier 39*	SF401B	37.48N	122.22W	1
Alcatraz Island*	SF402B	37.50N	122.25W	2
Richardson Bay Marshes	SF420A	37.56N	122.30W	3
Corte Madera Marshes	SF425A	38.56N	122.30W	4
San Rafael Creek Marsh	SF426A	37.58N	122.29W	5
Marin Islands	SF427A	37.58N	122.28W	6
Castro Rocks*	SF451A	37.50N	122.24W	7
Richmond Eelgrass Beds	SF452A	37.58N	122.24W	8
Richmond Inner Harbor/Hoffman Marsh	SF454A	37.45N	122.20W	9
Berkeley Eelgrass Beds	SF457A	37.51N	122.19W	10
Emeryville Lagoon/Marsh	AF458A	37.50N	122.19W	11
Alameda Eelgrass Beds	SF302C	37.45N	122.16W	12
San Leandro Bay	SF303A	37.45N	122.13W	13
Bay Farm Island Eelgrass Beds	SF304C	37.44.0N	122.15.5W	14
San Lorenzo Creek to Johnson Landing	SF305A	37.49N	122.09W	15
San Lorenzo Creek to Johnson Landing	SF305A	37.49N	122.09W	16
San Lorenzo Creek to Johnson Landing	SF305A	37.49N	122.09W	17
San Lorenzo Creek to Johnson Landing	SF305A	37.49N	122.09W	18
San Lorenzo Creek to Johnson Landing	SF305A	37.49N	122.09W	19
Yerba Buena Island	SF351A	37.48N	122.22W	20
South Basin/Hunters Point	SF352A	37.43N	122.23W	21
San Francisco Airport Mudflat	SF361A	37.46N	122.22W	22
Belmont Slough	SF362A	37.33N	122.15W	23
Steinberger Slough	SF363A	37.42N	122.14W	24
Bair Island	SF364A	37.22N	122.14W	25
Redwood Creek	SF365A	37.32N	122.12W	26
Corkscrew Slough	SF366A	37.31N	122.14W	27
Greco Island/Ravenswood Slough	SF367A	37.31N	122.12W	28
Castro Creek/Marshes	SF501A	37.58N	122.24W	29
Pinole Point Marshes - South	SF503A	37.59N	122.21.6W	30
China Camp Marsh	SF552A	38.00N	122.28W	31

[1]All latitudes/longitudes are in degrees and minutes.
[2]See Figure 2.
*Booming locations below size-threshold of SIMAP mapping (not included in modeling)

Protective booming would reduce the potential for oiling of sensitive locations, though not completely eliminate the possibility that these locations would be oiled to some extent. The SIMAP modeling took into account the type of boom and it ability to withstand different wave heights and current speeds. When the wave heights and/or current speeds were higher than the specifications for the booms, oil could pass the booms and enter sensitive coastal locations or inlets. Oil could also pass under booms when the oil was in the water column.

Costs were also modeled for operations with dispersant application as the primary on-water response strategy. While dispersant use is widely used internationally as an effective response strategy, particularly from a cost perspective (Etkin 1998*b*), it has not been used in many US spills because of lingering concerns over the potential environmental impacts of chemically-dispersed oil and the dispersants themselves.

With the development of newer dispersant chemical formulations and increasing knowledge of the environmental implications of dispersant application (Etkin 1999*b*), there has been a re-examination of the potential use of dispersants in US spill responses. An ecological risk assessment study performed for the California Office of Spill Prevention and Response and US Coast Guard (Pond *et al*. 2000) and personal communications with the US Coast Guard indicated that chemical dispersion will likely become a viable response option in the San Francisco Bay area during the next two to five years.

The use of chemical dispersants in a particular location and for a particular spill scenario depends on receiving the appropriate approval and authorization of federal and state authorities. This is generally done in advance by an evaluation of the environmental benefits and the risks of potential impacts by state and federal natural resource trustees to develop a pre-authorization or pre-approval agreement or memorandum of understanding. These documents and agreements allow decisions on dispersant use to be made within the appropriate window of opportunity for greatest dispersant effectiveness (generally from within a few hours to the first full day after the oil spill initiates).

Costs for dispersant operations include both the on-water dispersant response and shoreline cleanup. Depending on the effectiveness of the dispersant chemicals under field conditions, the shoreline cleanup costs would be reduced to different extents. The greater the amount of oil dispersed offshore, the less that would impact the shoreline. Costs were determined for both lower and higher dispersant effectiveness. While shoreline impacts would be reduced by dispersant application, more oil would enter the water column with the use of dispersants. The chemically dispersed oil and the dispersant chemicals could have impacts on important natural resources, e.g., fish and wetlands, which are not accounted for in this modeling.

In all cases, response costs were estimated based on known regional or regionally-adjusted per-unit costing (and modeling of necessary personnel and equipment based on extensive analyses of incident action plans from previous oil spill cases and the California Area Contingency Plan for San Francisco Bay (US Coast Guard 2001). Costs were updated to 2001 dollars with cost projections for the years 2002-2010, based on projection of Consumer Price Indices.

3.0 Cost Estimations For On-Water Mechanical Response Operations

Inherent in the modeling of on-water containment and recovery operation costs are the following assumptions (based on Etkin 2001*a*; Michel and Cotsapas 1997):

1. The mechanical containment and recovery operations and protective booming are set up as described in the Area Contingency Plan (US Coast Guard 2001).
2. The pay scales for workers are as shown in Table 3. These pay scales are based on a comprehensive survey of Basic Ordering Agreements made with the US Coast Guard (USCG) Office of Maintenance and Logistics for the 11th US Coast Guard District. The hourly pay figures have been updated to 2001 $.
3. Wages are paid as: 67% straight wages, 20% premium wages, and 13% overtime wages. Cleanup crews work for 12-hour workdays.
4. Crews consist of: 1% project managers, 3% supervisors, 67% skilled laborers, and 29% unskilled laborers. Worker numbers and ratios of worker types were verified by a review of Area Contingency Plans (*e.g.,* North Coast California; Central Coast California; San Francisco Bay & Delta, Baltimore; Long Angeles/Long Beach; Mid-Coast Atlantic; Galveston, Texas; Port Arthur, Texas; San Diego; New York/New Jersey), Incident Action Plans from past spills (*e.g.,* Cape Mohican; PEPCO Pipeline; New Carissa; Morris J. Berman), and oil company contingency plans. Adjustments to work requirements for each oil type and shoreline type were made by professional judgment based on spill case studies and oil behavior by oil type (evaporation rate and dispersion rate) as calculated by SIMAP.
5. The rental rates for equipment are as shown in Table 4. These rental rates are based on a comprehensive survey of Basic Ordering Agreements made with the USCG Office of Maintenance and Logistics for the 11th US Coast Guard District. The daily rental figures have been updated to 2001 $. Equipment requirements were determined by a review of a selection of Area Contingency Plans, Incident Action Plans from previous spills, mandated response capability requirements in the US Coast Guard Response Capability standards (see Appendix B) , and professional judgment based on spill case studies.
6. Actual oil recovery rate of *floatin*g oil is 15% (used for determining disposal costs).
7. Dispersed or evaporated oil cannot be recovered by mechanical recovery techniques.
8. Disposal rates for collected oil-water mixtures and oily waste and debris are as shown in Table 5. These rates are based on a comprehensive survey of Basic Ordering Agreements made with the US Coast Guard Office of Maintenance and Logistics for the all US Coast Guard Districts. Disposal cost figures have been updated to 2001 $.
9. There are no dispersant or other chemical applications implemented in the response.
10. The oil slick is assumed to cover the surface water areas shown by the SIMAP modeling runs.
11. Emulsification increases oily liquid volume by four. No. 2 (diesel) fuel oil and gasoline do not emulsify.
12. Costs for shore-based support for skimming systems are 12% of on-water costs.
13. Helicopter overflights are charged for 12-hour days for the entire time oil is present on the water surface (one helicopter is employed for smaller spills, two for larger.)
14. *Oil removal is not taken into account to discount the oil on the shoreline.*

15. Basic salvage and lightering costs (source control) are assumed to be $5 million for the freighters (HFO spills), $9 million for the product tankers (diesel and gasoline spills), and $12 million for the crude tankers (crude spills), based on an extrapolation of salvage/lightering costs in the T/B *Morris J. Berman* spill (Etkin 1995). These costs include costs for the US Navy Supervisor of Salvage (SUPSALV).
16. Base costs for mobilization of response contractors and equipment are assumed to be $500,000 (based on spill cost information on several spills as well as mobilization costs for oil spill preparedness drills). These costs are incurred regardless of whether or not an actual spill response operation is initiated.
17. Other costs were assumed to be as shown in Appendix B.

Table 3

Average Hourly Pay Scale for Oil Spill Response Personnel (2001 $)			
Labor Type	**Straight Pay**	**Overtime Pay**	**Premium Pay**
Unskilled labor	$42.02	$57.82	$69.03
Skilled labor	$46.34	$63.69	$100.86
Supervisor	$63.00	$76.52	$79.19
Project Manager	$83.22	$101.34	$113.17
Workboat Operator	$51.56	$66.91	$66.61
Biologist	$71.86	$84.62	$87.89
Vacuum Truck Operator	$42.31	$55.45	$60.17
Skimmer Craft Operator	$60.14	$71.68	$76.93
Based on Basic Ordering Agreements Survey for 11th USCG District (Etkin 1998*a*)			

Table 4

Typical Rental Rates for Oil Spill Response Equipment (2001 $)	
Equipment Type	**Rental Rates**
Kepner Sea Curtain (Boom) (12" x 100')	$124/day
Kepner Sea Curtain (Boom) (18" x 100')	$126/day
Kepner Sea Curtain (Boom) (24" x 100')	$151.day
Harbor Oil Boom (36")	$300/day
MFG Weir Skimmer (1,500 gal/hour)	$192/day
Class Skimmer	$420/day
Weir Floating Skimmer	$217/day
Walosep Skimmer	$765/day
Based on Basic Ordering Agreements Survey for 11th USCG District (Etkin 1998*a*)	

Table 5

Average Oil Spill Cleanup Contractor Oily Waste Disposal Rates	
Oil/Water Mixtures	**Oil and Oily Debris**
$0.65/gallon	$200/cubic yard
Based on Basic Ordering Agreements Survey for 11th USCG District (Etkin 1998*a*)	

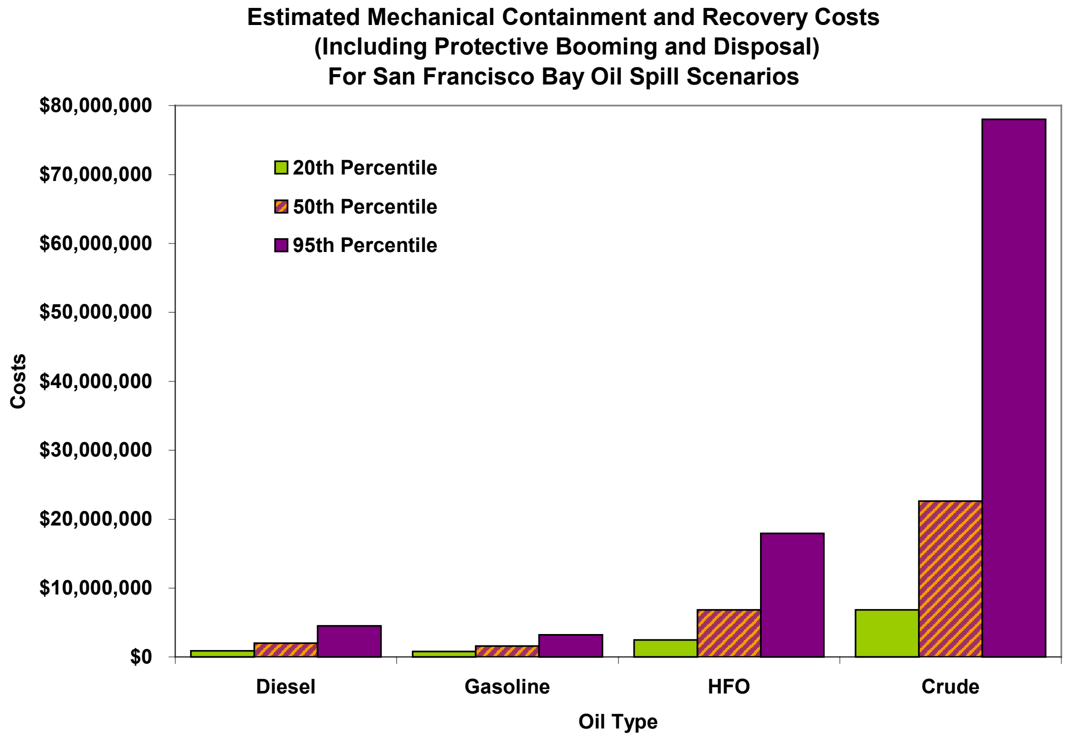
Estimated costs for mechanical containment and recovery personnel and equipment and costs for the twelve scenarios are shown in Tables 6 and Figure 3. (*Note: these costs do not include shoreline cleanup costs. Shoreline cleanup costs are covered in Section* 4.0.)

Table 6

On-Water Mechanical Response and Protective Booming Costs For San Francisco Bay Spill Scenarios					
Spill Scenario		**Estimated Scenario Costs**			
Oil Type	**Amount Spilled**	**Equipment Costs[1]**	**Personnel Costs[2]**	**Disposal/ Decontamination Costs[3]**	**Total Costs[2,3]**
Diesel	50,000 gal	$685,000	$200,000	$8,000	**$893,000**
	270,000 gal	$1,292,000	$660,000	$58,000	**$2,010,000**
	1,250,000 gal	$2,638,000	$1,460,000	$414,000	**$4,512,000**
Gasoline	50,000 gal	$653,000	$170,000	$2,000	**$825,000**
	270,000 gal	$1,138,000	$460,000	$22,000	**$1,620,000**
	1,250,000 gal	$2,110,000	$990,000	$107,000	**$3,207,000**
Heavy Fuel Oil	25,000 gal	$1,308,000	$1,010,000	$151,000	**$2,469,000**
	100,000 gal	$1,916,000	$4,310,000	$591,000	**$6,817,000**
	410,000 gal	$3,044,000	$12,470,000	$2,401,000	**$17,915,000**
Crude	100,000 gal	$1,976,000	$4,290,000	$573,000	**$6,839,000**
	600,000 gal	$4,373,000	$14,730,000	$3,525,000	**$22,628,000**
	3,000,000 gal	$16,870,000	$43,410,000	$17,744,000	**$78,024,000**

Based on Etkin 2001*a*
[1]Includes additional $500,000 initial mobilization cost; does not include disposal costs.
[2]Includes 12% shore-based support costs.
[3]Includes decontamination costs of $5.70 per gallon spilled for HFO and crude spills; disposal of recovered oil at $0.65/gallon recovered, taking into account emulsification of oil (recovery limited to 15% floating oil *after evaporation and dispersion* as determined by SIMAP modeling).

Figure 3



Disposal costs for recovered oil/water mixtures were determined on the basis of $0.65 per gallon oil/water mixture. Only 15% of floating oil was assumed to be recovered with an emulsification factor of approximately four (oil/water mixtures contain 25% oil, 75% water). Diesel fuel and gasoline were assumed not to emulsify. Oil fate (mass balance) outputs from SIMAP were analyzed to determine the amount of oil that would reasonably be recovered and the amount of waste oil/water mixture that would have to be disposed of (see Appendix C).

Mechanical containment/recovery costs as presented here assume that the response has been carried out *as described in the Area Contingency Plans* (US Coast Guard 2001) in terms of the amount of equipment and personnel deployed. The actual effectiveness of the on-water mechanical recovery operations is assumed to be negligible as reflected in the fact that *all* of the spilled oil is assumed to impact the shoreline. There has been no discounting of shoreline oiling based on mechanical recovery. In this sense, the mechanical recovery costs as presented (when coupled with the appropriate shoreline response costs in the next section) reflect the “worst case” for the specific runs that were determined to constitute the 20th, 50th, and 95th percentile cases in this study. Situations in which there are extraordinary expenditures for mechanical recovery operations are discussed in Section 10.0.

4.0 Cost Estimations For Shoreline Response Operations

Shoreline response costs were estimated based on the amount of shoreline oiled as modeled by French McCay et al. (2002) using SIMAP. Each of six shoreline types was analyzed separately – rocky, gravel, sand beach, mudflat, wetland, and artificial shoreline (concrete, piers, jetties). The four oil types – gasoline, diesel, heavy fuel oil, and crude – were also factored in separately as they present very different challenges in cleanup responses, as shown in Table 7.

Gasoline and diesel fuel will dissolve into water and evaporate over the course of hours into the first days after a spill. They may also penetrate deeply into shoreline sand and gravel where they can persist for longer periods of time. While gasoline and diesel cannot readily be *seen* when onshore, their irritating fumes can cause problems and necessitate that cleanup measures (such as sand removal) be taken.

Crude and HFO persist on water surfaces and on impacted shoreline surfaces. Their darker color makes them readily visible, causing the need for removal from shoreline surfaces and structures. Their sticky consistency makes them more difficult to remove.

Table 7

Influence of Oil Properties on Oil Impact in Environment[1]				
Oil Type	**Viscosity**	**Adhesion**	**Penetration**	**Degradation**
Gasoline	1	1	5	4
Diesel	2	2	4	1
Crude	4	4	2	3
Heavy fuel oil	5	5	1	5
[1]Lower numbers indicate more favorable conditions to the environment and faster recovery after a spill (based on Fingas 2001).				

The unit area shoreline cleanup costs used in modeling for each shoreline type by oil thickness are shown in Table 8. A rule of thumb of 0.06 worker-days per m^2 was used to estimate worker numbers at a rate of $1,000 per worker-day, based on information from oil spill response organizations (Michel and Cotsapas 1997). These values were verified based on a comprehensive survey of historical cost data, incident action plans, contingency plans, and case studies (Etkin 2001*b*). Professional judgment was also used to discount or increase unit costs based on the relative difficulty of removing each oil type based on the criteria in Table 7.

The unit costs were multiplied by shoreline area for each shoreline type by thickness oiled for each model run. The total shoreline cleanup costs for each run is the sum of costs per shoreline type based on the unit cost:

> $\mathbf{SC_i = C_i A_i}$, Where, SC_i = shoreline cleanup (oil removal) cost for shoreline type, *i* (in \$);C_i = unit shoreline cleanup cost for shoreline type, *i* (in \$/m^2); A_i = area of shoreline type, *i*, oiled

$$SC_{total} = SC_{rocky} + SC_{gravel} + SC_{sand} + SC_{mudflat} + SC_{wetland} + SC_{artificial}$$

Table 8

Shoreline Cleanup Cost Factors (2001 $/m^2) for Personnel and Equipment[1]								
Shoreline Type	**Thickness on Shoreline**							
	Gasoline		**Diesel**		**Crude**		**Heavy Fuel**	
	0.1-1 mm	**>1mm**	**0.1-1 mm**	**>1mm**	**0.1-1 mm**	**>1mm**	**0.1-1 mm**	**>1mm**
Rocky shoreline	$3	$5	$8	$10	$24	$32	$25	$63
Gravel beach	$3	$5	$8	$10	$24	$32	$25	$63
Sand beach	$6	$8	$10	$13	$31	$40	$45	$113
Mud flat	$6	$8	$11	$14	$34	$44	$28	$70
Wetland	$6	$8	$11	$14	$34	$44	$30	$75
Artificial	$3	$5	$8	$10	$24	$32	$25	$63
[1]Excluding government costs, monitoring, spill management, decontamination, disposal								

4.1 Shoreline Cleanup Cost Summary

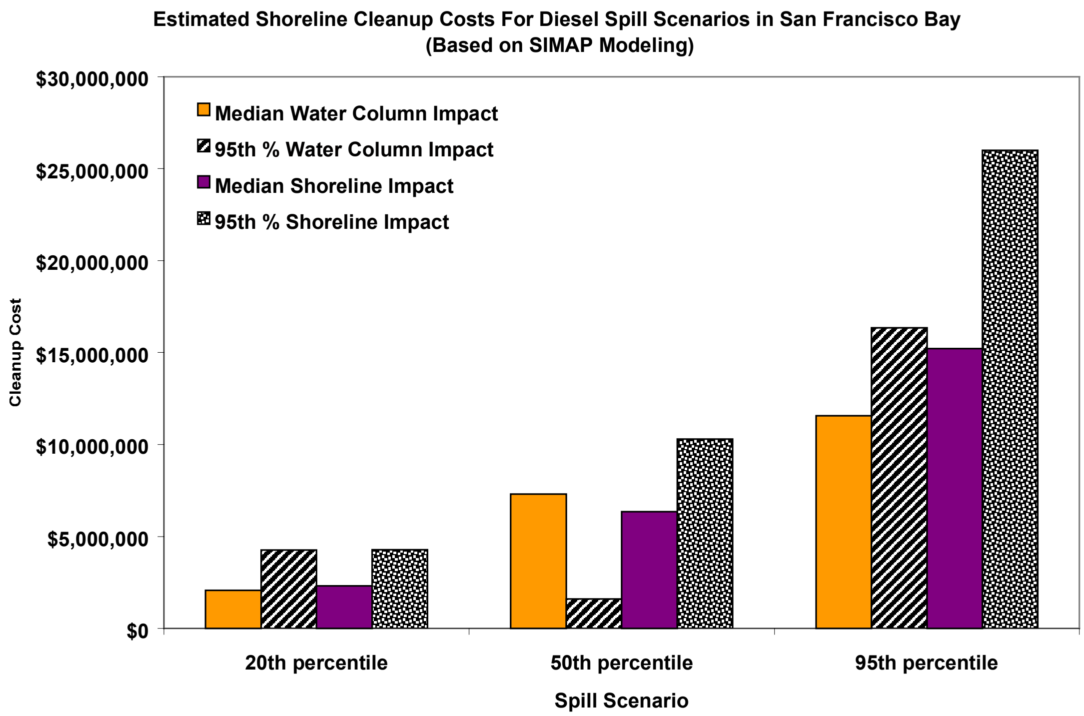
Median and maximum shoreline cleanup costs are shown in Table 9. Shoreline cleanup costs were estimated for model runs representing median (50th percentile) and worst (95th percentile) impacts for water column and shoreline. Note that the scenario runs with the worst water column impact have lower shoreline cleanup costs than the worst shoreline impact scenarios since more oil is remaining in the water column rather than stranding on shorelines. For example, shoreline cleanup for the worst *water column* impact run for a 25,000-gallon HFO spill cost $4.5 million compared to $5.7 for the worst shoreline oiling scenario run. Overall, the runs that result in median and worst water column impact and are rarely the same as the ones that result in median and worst shoreline impact.

Table 9: Estimated Total Shoreline Cleanup Costs[1] For San Francisco Bay Spill Scenarios Based on SIMAP Modeling and ERC Cost Analysis					
Scenario		**Estimated Shoreline Cleanup Costs**			
Fuel	**Spill Size (gallons)**	**Median Shoreline Impact**	**Worst.[2] Shoreline Impact**	**Median Water Column Impact**	**Worst.[2] Water Column Impact**
Diesel	50,000	$2,310,000	$4,280,000	$2,080,000	$4,260,000
	270,000	$6,336,000	$10,280,000	$7,303,000	$1,593,000
	1,250,000	$15,200,000	$26,000,000	$11,570,000	$16,340,000
Gasoline	50,000	$14,000	$39,000	$16,000	$2,000
	270,000	$108,000	$416,000	$150,000	$116,000
	1,250,000	$1,116,000	$1,963,000	$295,000	$1,918,000
Heavy fuel oil	25,000	$3,370,000	$5,670,000	$3,370,000	$4,450,000
	100,000	$20,770,000	$36,200,000	$35,940,000	$28,730,000
	410,000	$47,140,000	$91,260,000	$56,410,000	$55,580,000
Crude	100,000	$8,510,000	$14,990,000	$11,470,000	$14,650,000
	600,000	$21,670,000	$39,870,000	$30,950,000	$16,580,000
	3,000,000	$48,120,000	$96,160,000	$43,390,000	$51,680,000
[1]**Costs include equipment and personnel costs, but not waste disposal costs.** [2]95th percentile.					

4.2 Shoreline Cleanup For Diesel Scenarios

The shoreline cleanup costs for the diesel spill scenarios for median and worst (95th percentile) *runs* on the basis of both water column and shoreline cost impact are compared in Figure 4. (However, for more detailed diesel response cost analyses, the median and worst *water column* runs were selected only.)

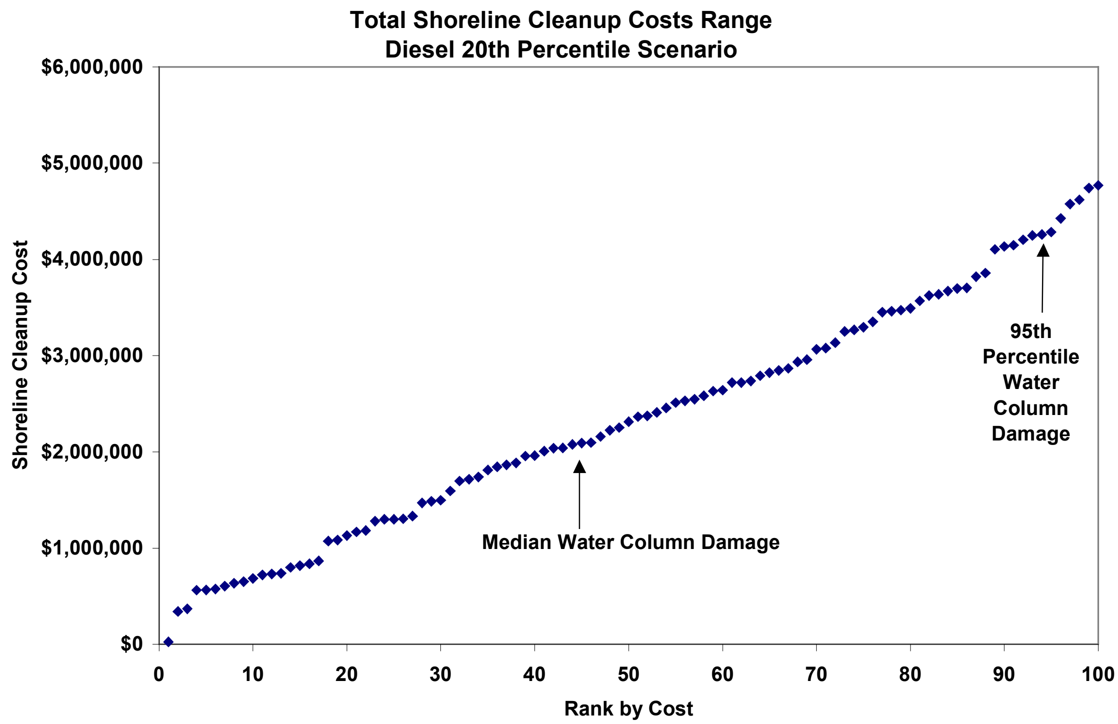
Figure 4

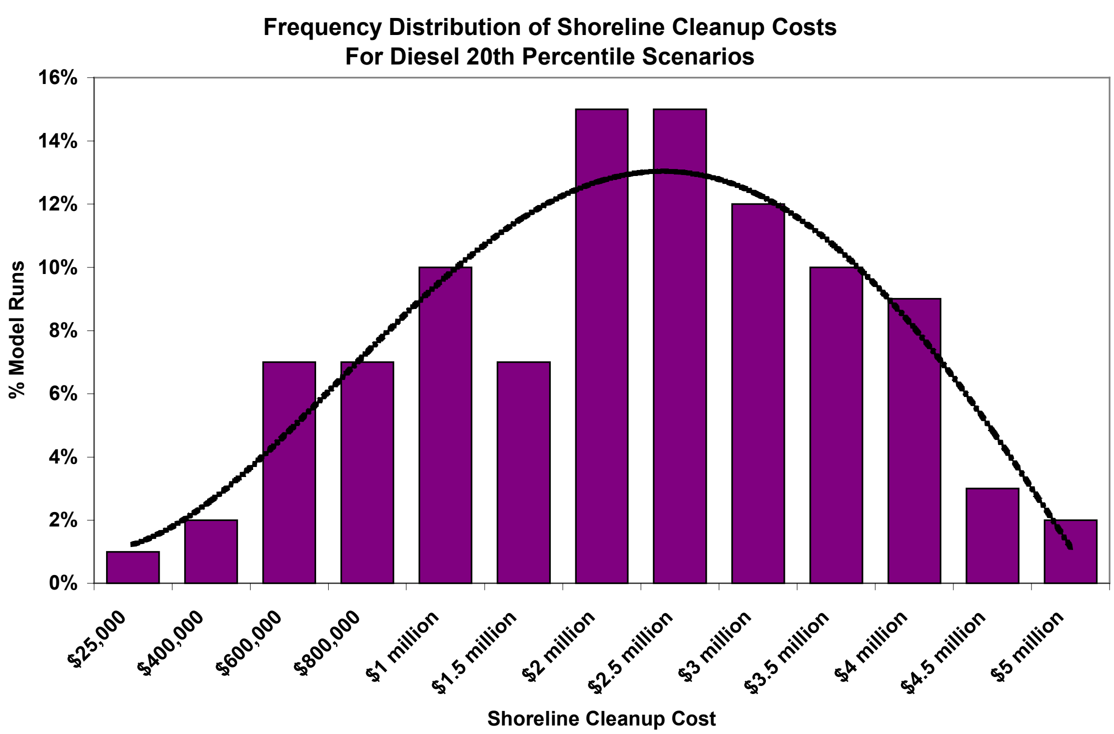


The percentile ranks are based on cost modeling for 100 separate SIMAP spill runs, each of which has a slightly different impact on the shoreline areas of the bay. Figures 5 and 6 show the range of costs for the SIMAP runs for the 20th percentile diesel *volume* scenario (50,000 gallons spilled). Figures 7 and 8 show the range of costs for the SIMAP runs for the 50th percentile diesel *volume* scenario (270,000 gallons spilled). Figures 9 and 10 show the range of costs for the SIMAP runs for the 95th percentile diesel *volume* scenario (1,250,000 gallons spilled).

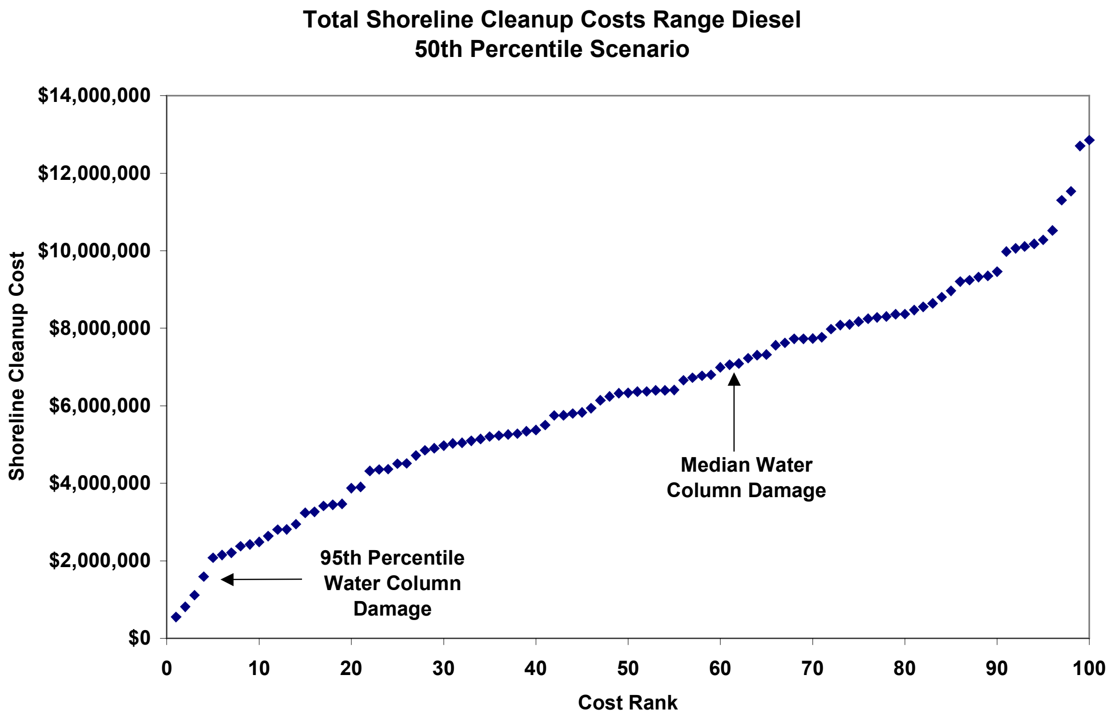
Since the shorelines are weighted differently in terms of the per-square meter cleanup costs, the amount of each type of shoreline impacted is important in determining the costs. The areas of shoreline oiled by diesel and the type of shoreline involved are shown in Figures 11 – 25. Figures 17 – 19 show for all 100 runs of the SIMAP model the average percentage of total shoreline costs that each shoreline type comprises. (*e.g.,* 75% mudflat means that on average, 75% of total shoreline cleanup costs are made up of mudflat cleanup costs.)

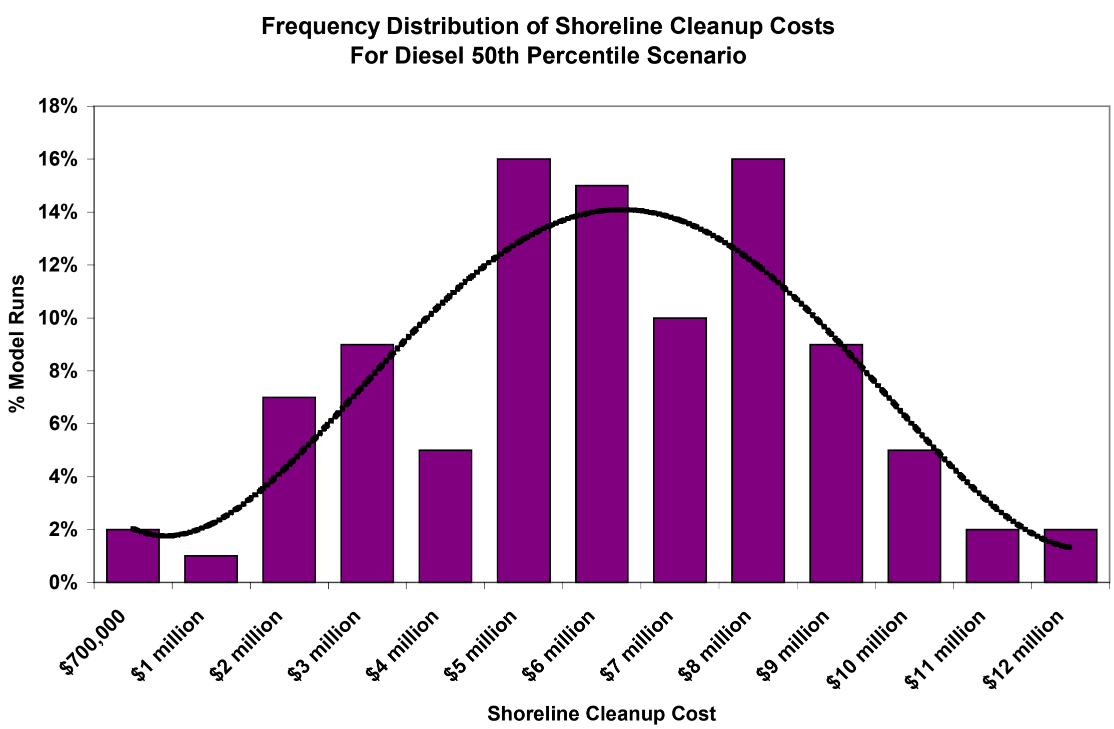
Figures 5 and 6



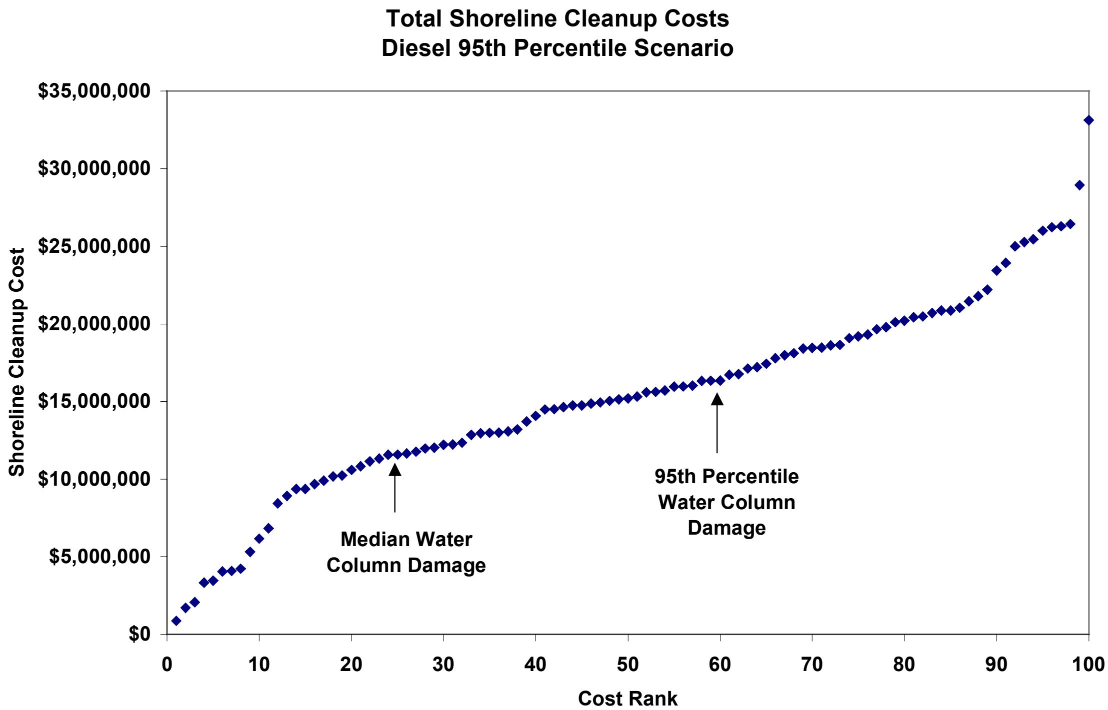


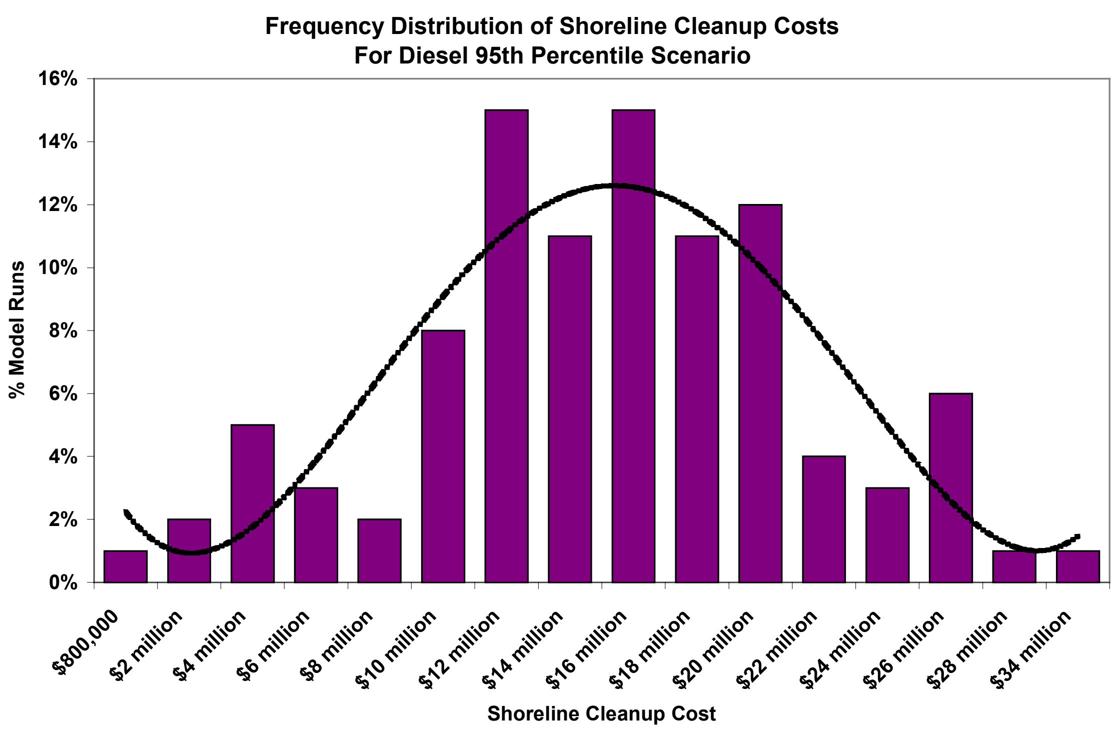
Figures 7 and 8



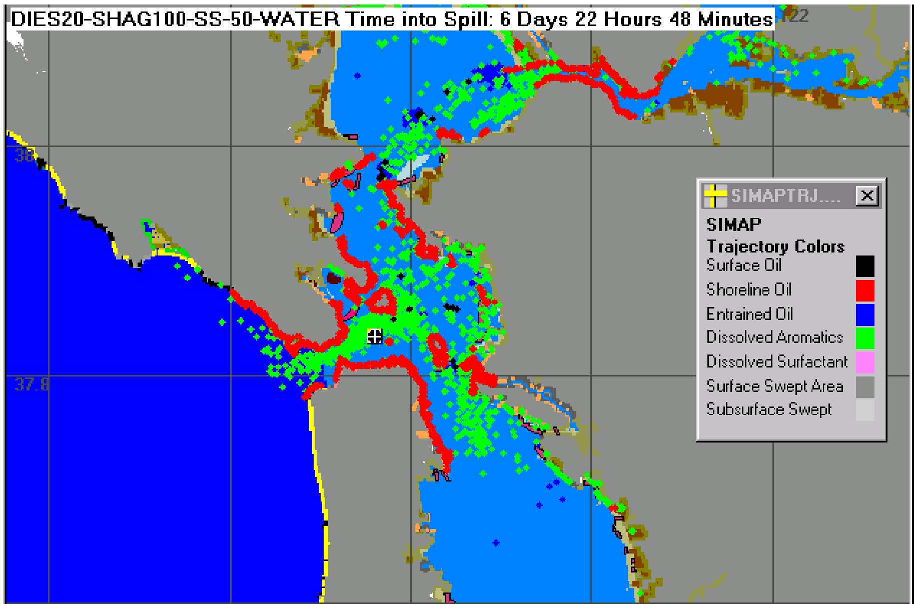


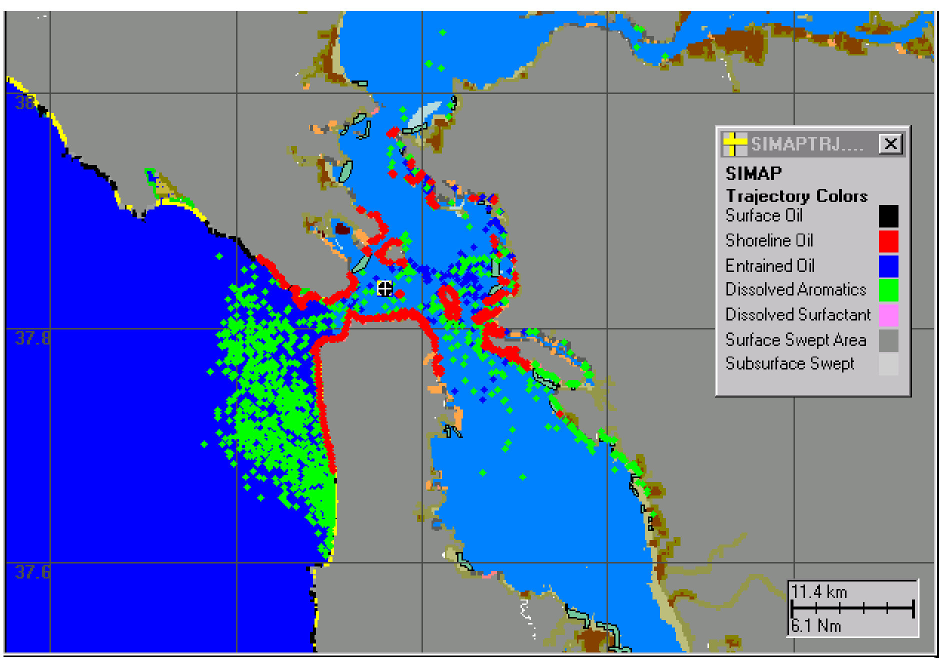
Figures 9 and 10



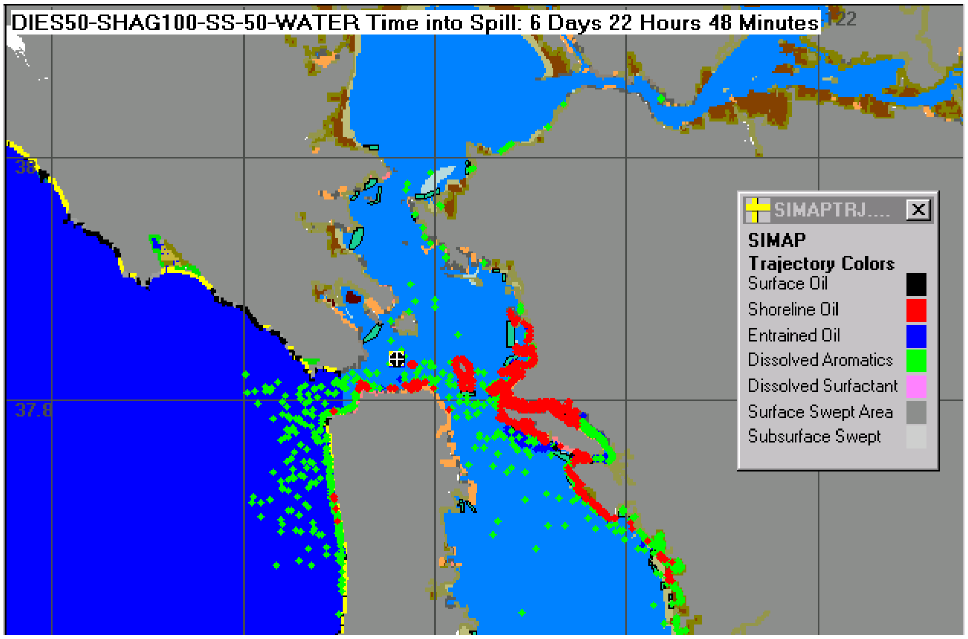


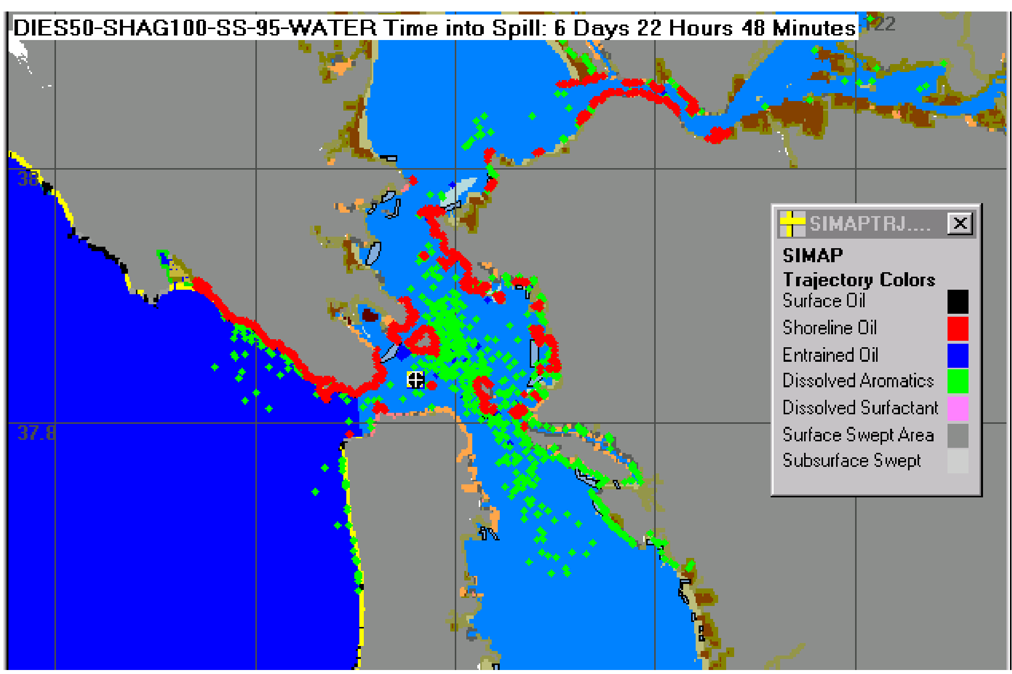
Figures 11 and 12: Oiling for the 20th Percentile Volume Diesel Scenarios (Median Water Column Damage and Worst Water Column Damage) with shoreline oiling shown in red.



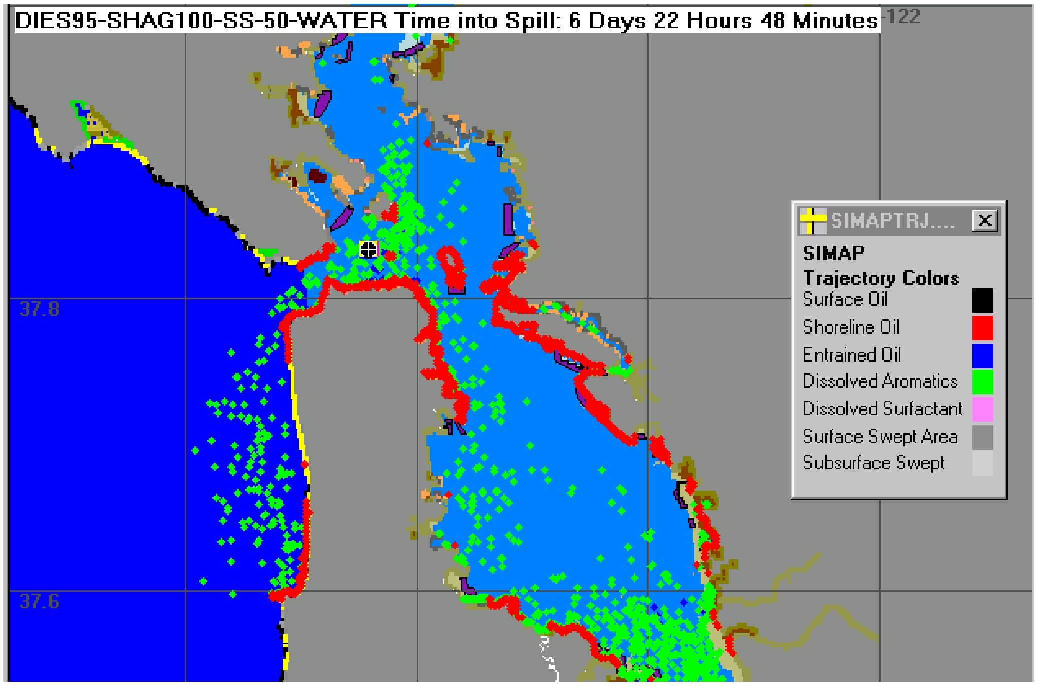


Figures 13 and 14: Oiling for the 50th Percentile Volume Diesel Scenarios (Median Water Column Damage and Worst Water Column Damage) with shoreline oiling shown in red.





Figures 15 and 16: Oiling for the 95th Percentile Volume Diesel Scenarios (Median Water Column Damage and Worst Water Column Damage) with shoreline oiling shown in red.



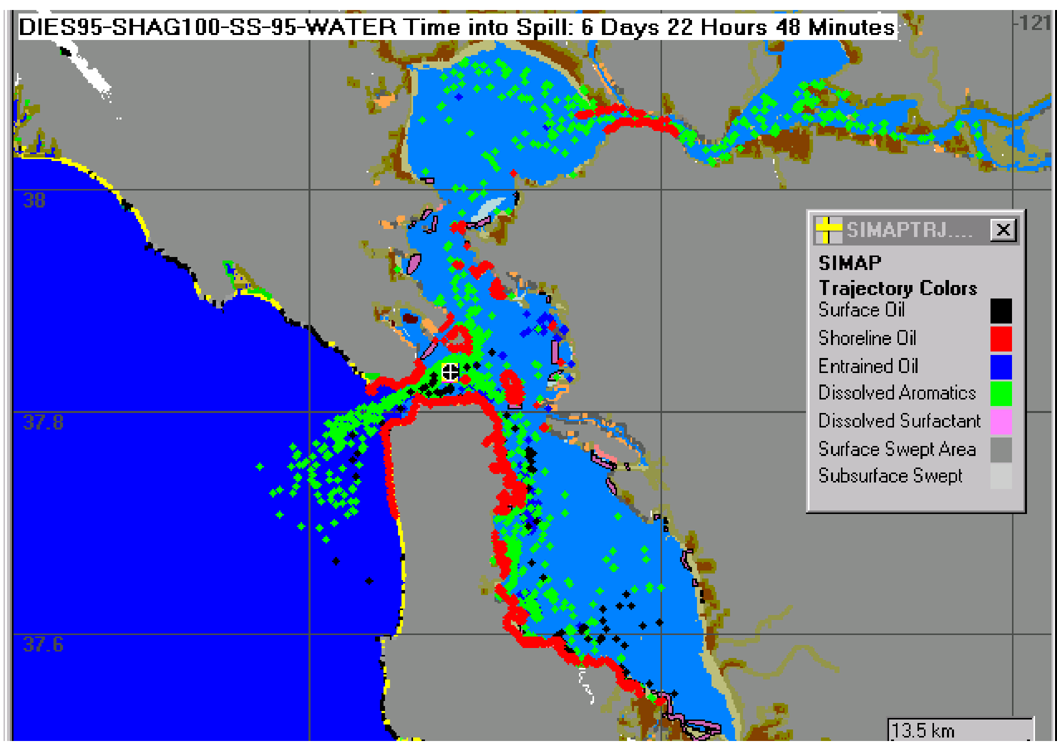


Figure 17: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Diesel 20th Percentile Scenario

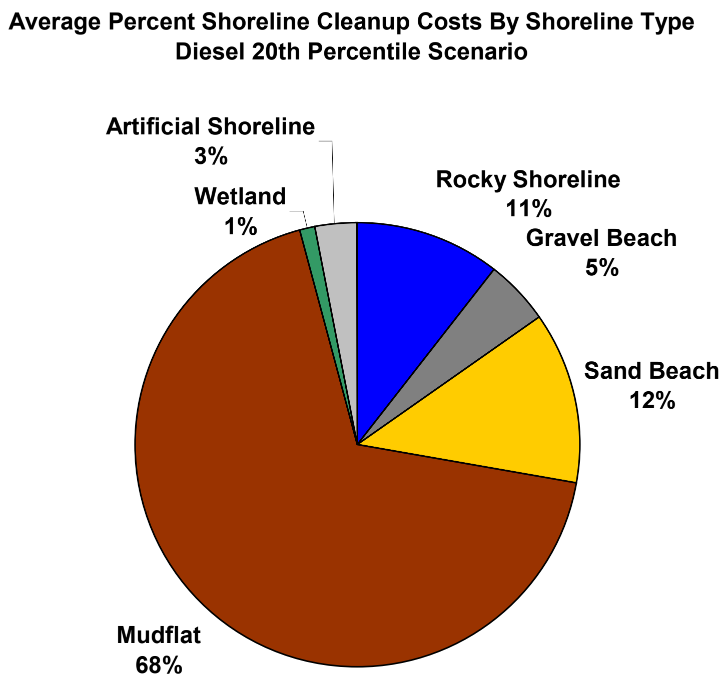


Figure 18: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Diesel 50th Percentile Scenario

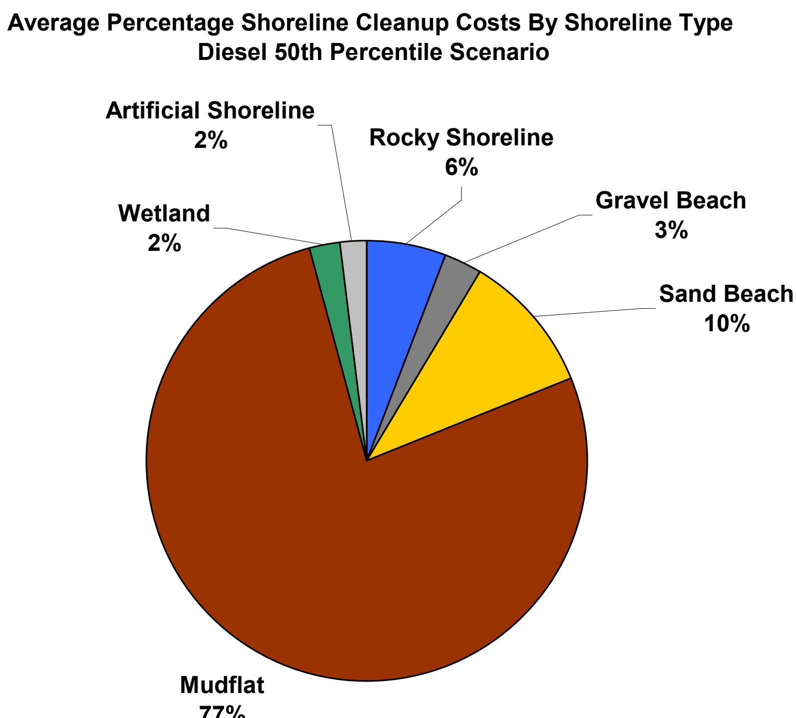
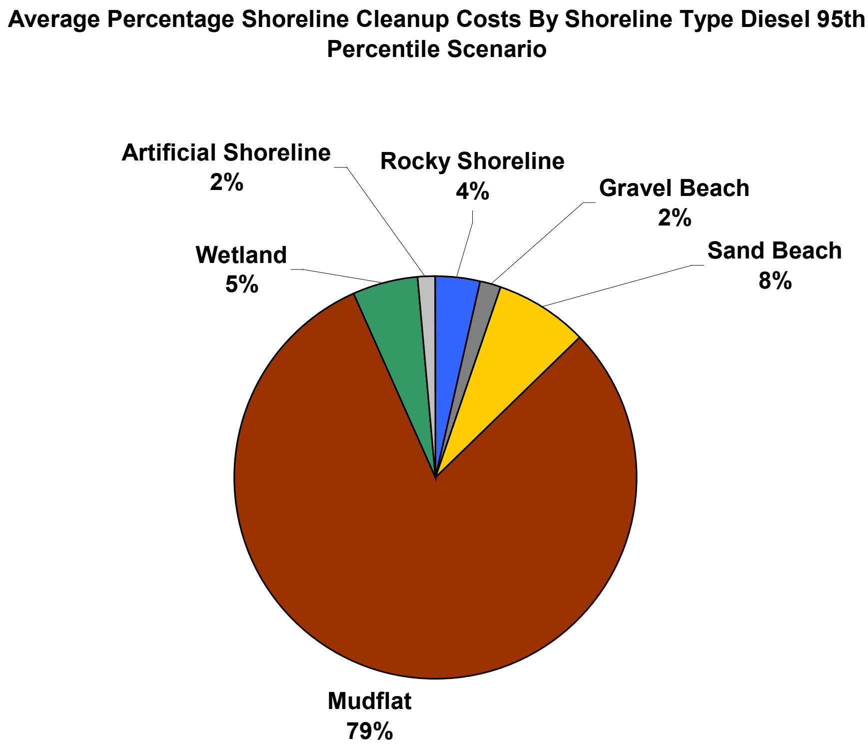
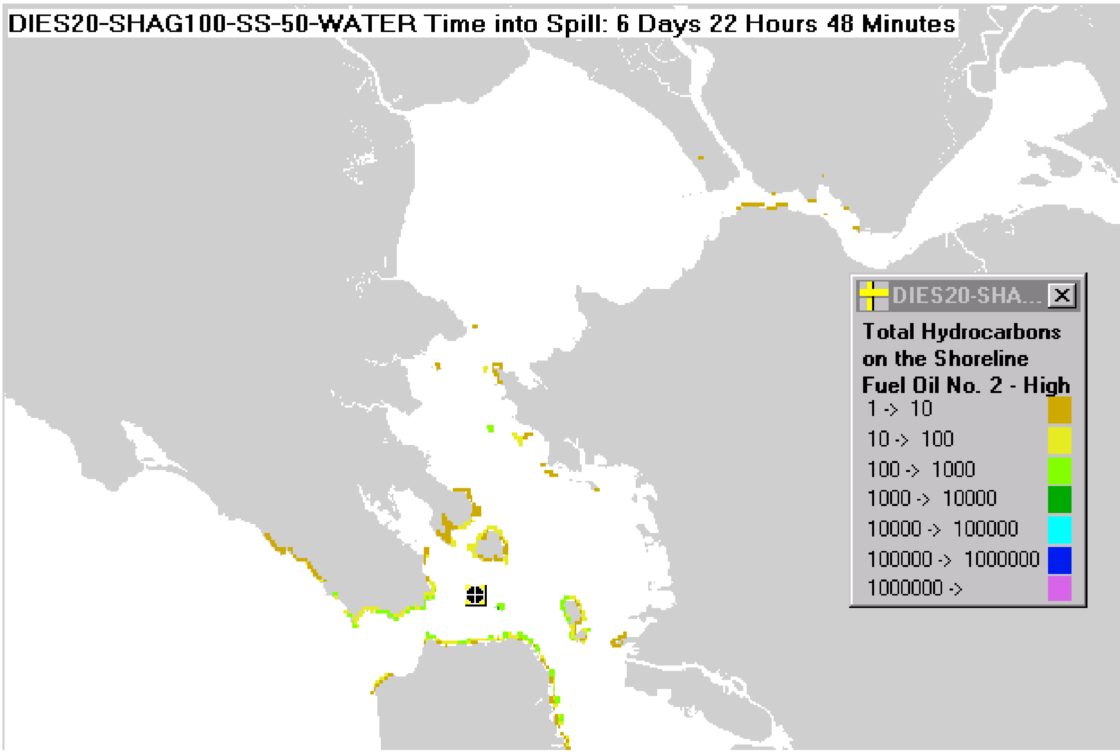
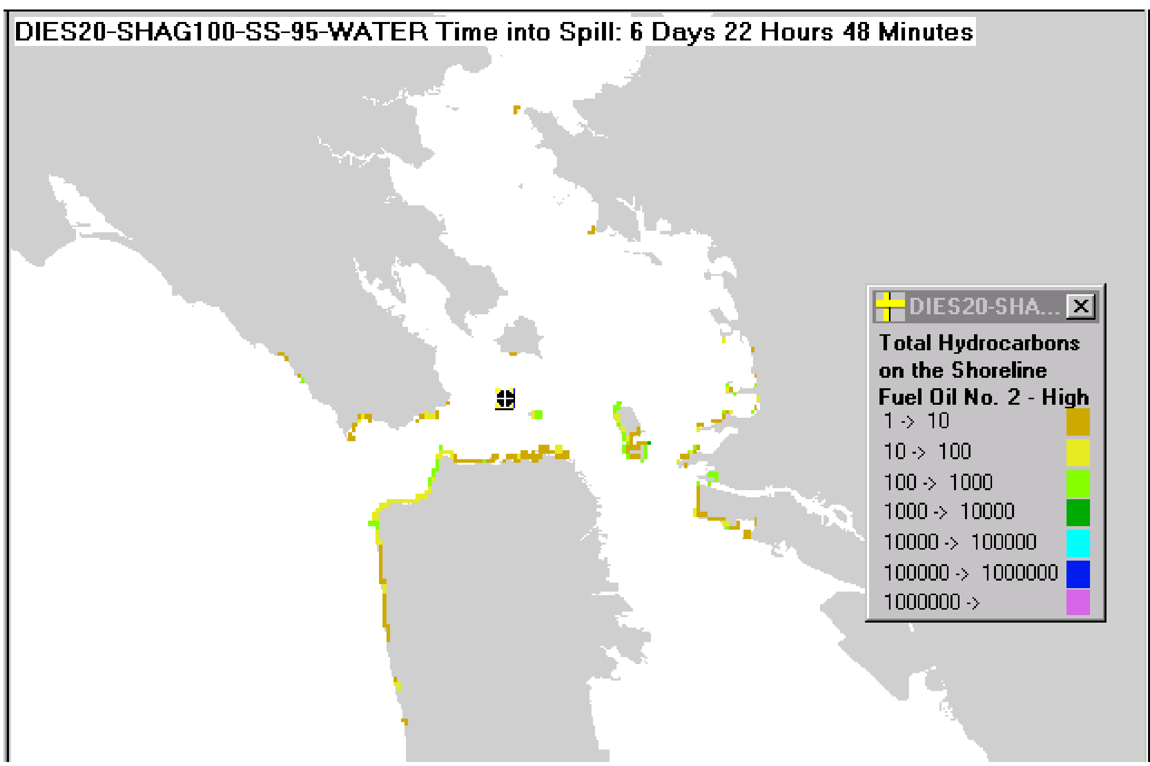


Figure 19: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Diesel 95th Percentile Scenario

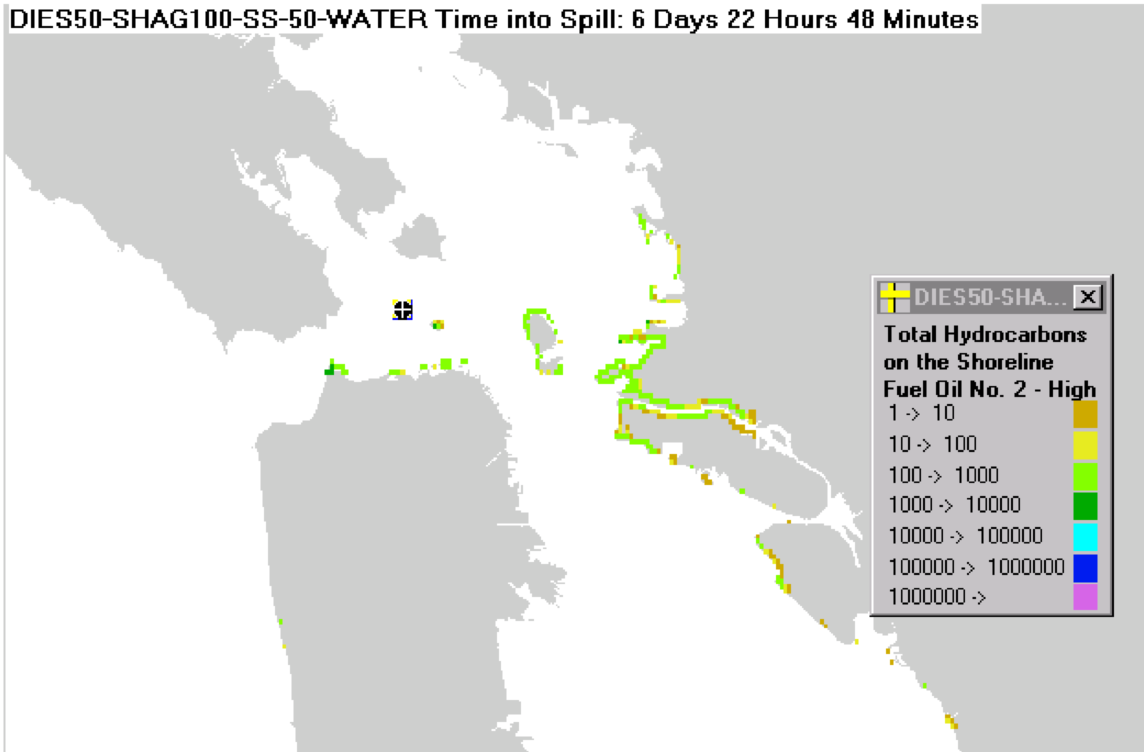


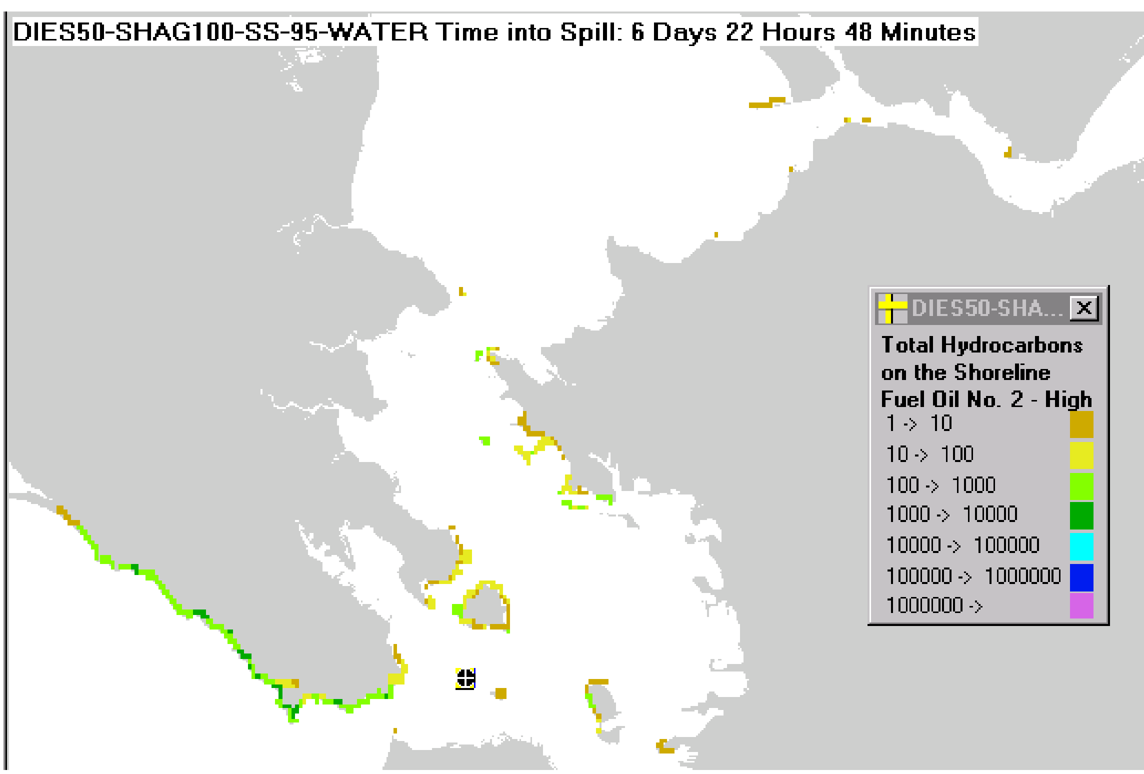
Figures 20 and 21: Shoreline Oiling Degree (g oil/m^2) For Diesel 20th Percentile Volumes (Median and Worst Water Column Damage)



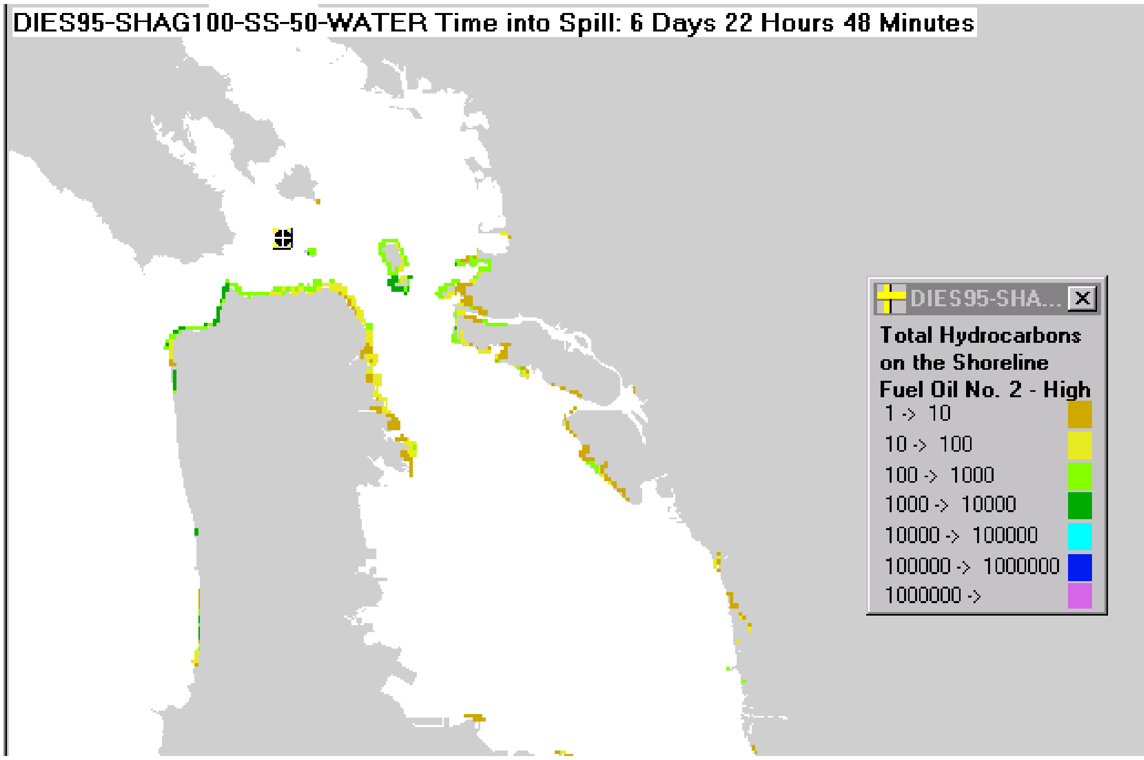


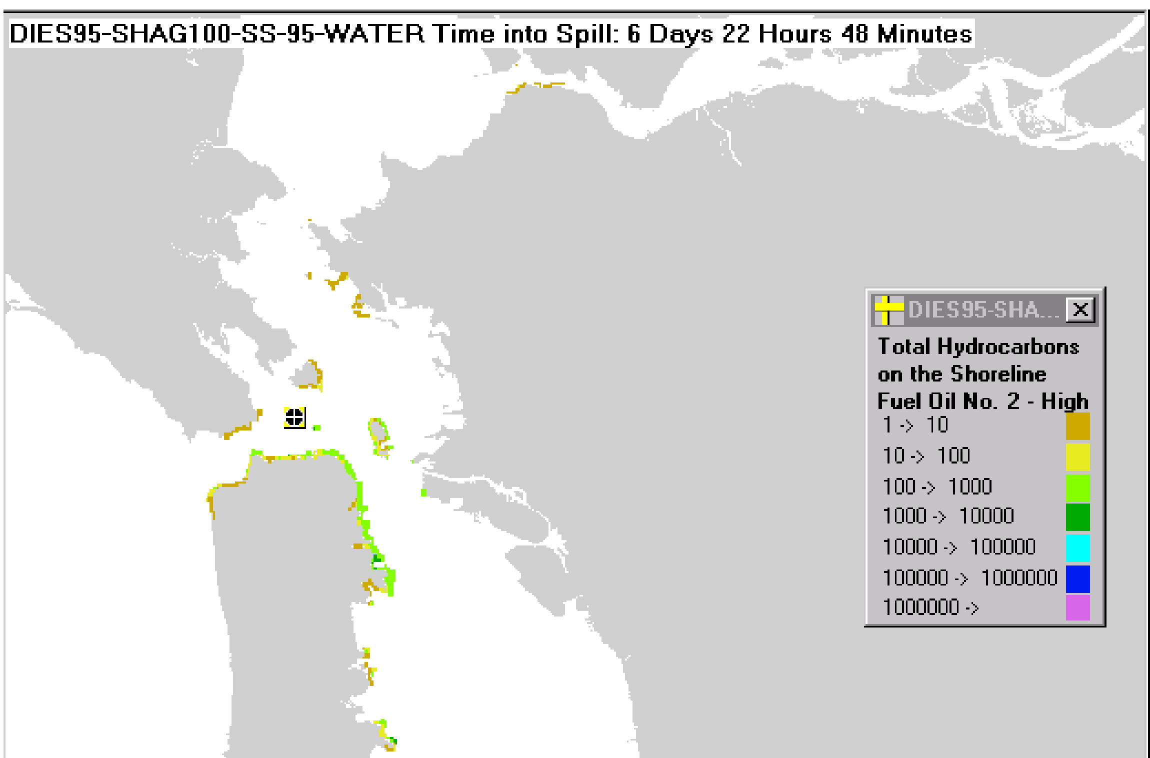
Figures 22 and 23: Shoreline Oiling Degree (g oil/m^2) For Diesel 50th Percentile Volumes (Median and Worst Water Column Damage)





Figures 24 and 25: Shoreline Oiling Degree (g oil/m^2) For Diesel 95th Percentile Volumes (Median and Worst Water Column Damage)

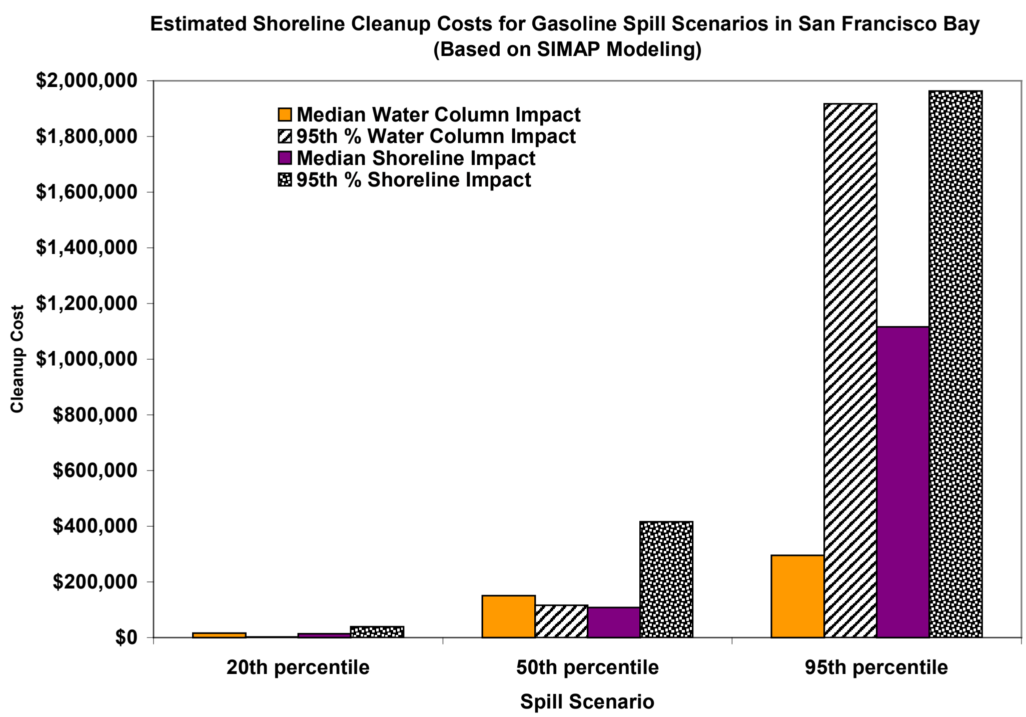




4.3 Shoreline Cleanup For Gasoline Scenarios

The shoreline cleanup costs for the gasoline spill scenarios for median and worst (95th percentile) *runs* on the basis of both water column and shoreline cost impact are compared in Figure 26. (However, for more detailed gasoline response cost analyses, the median and worst *water column* runs were selected only.)

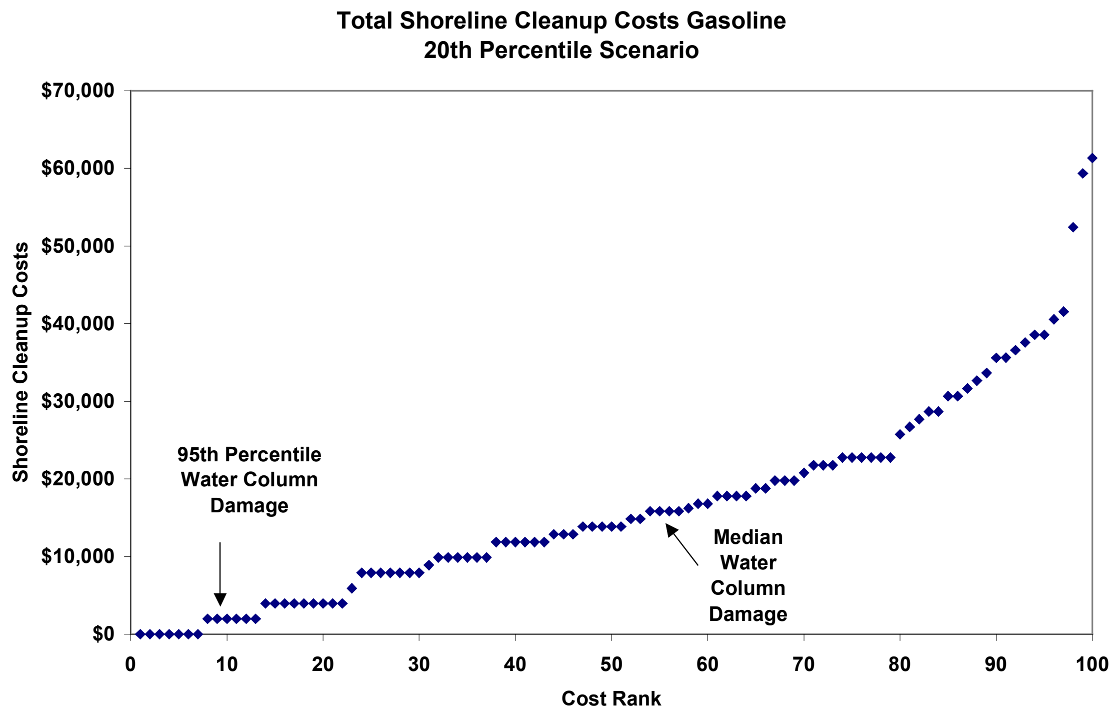
Figure 26

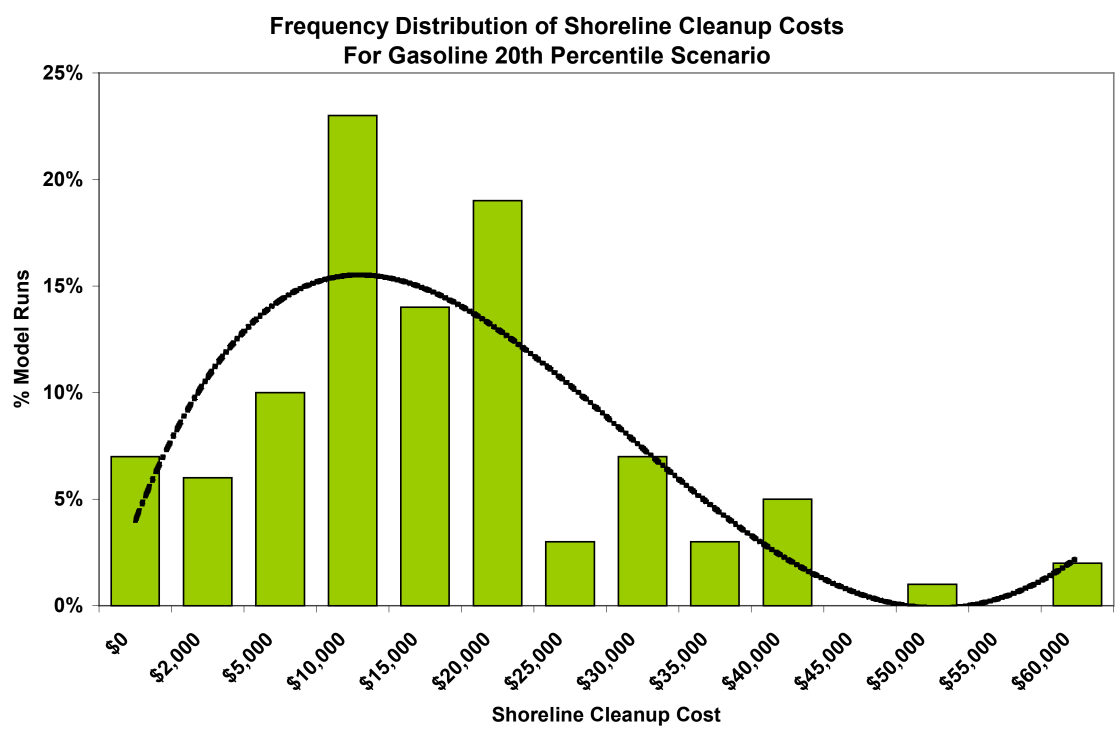


The percentile ranks are based on cost modeling for 100 separate SIMAP spill runs, each of which has a slightly different impact on the shoreline areas of the bay. Figures 27 and 28 show the range of costs for the SIMAP runs for the 20th percentile gasoline *volume* scenario (50,000 gallons spilled). Figures 29 and 30 show the range of costs for the SIMAP runs for the 50th percentile gasoline *volume* scenario (270,000 gallons spilled). Figures 31 and 32 show the range of costs for the SIMAP runs for the 95th percentile gasoline *volume* scenario (1,250,000 gallons spilled).

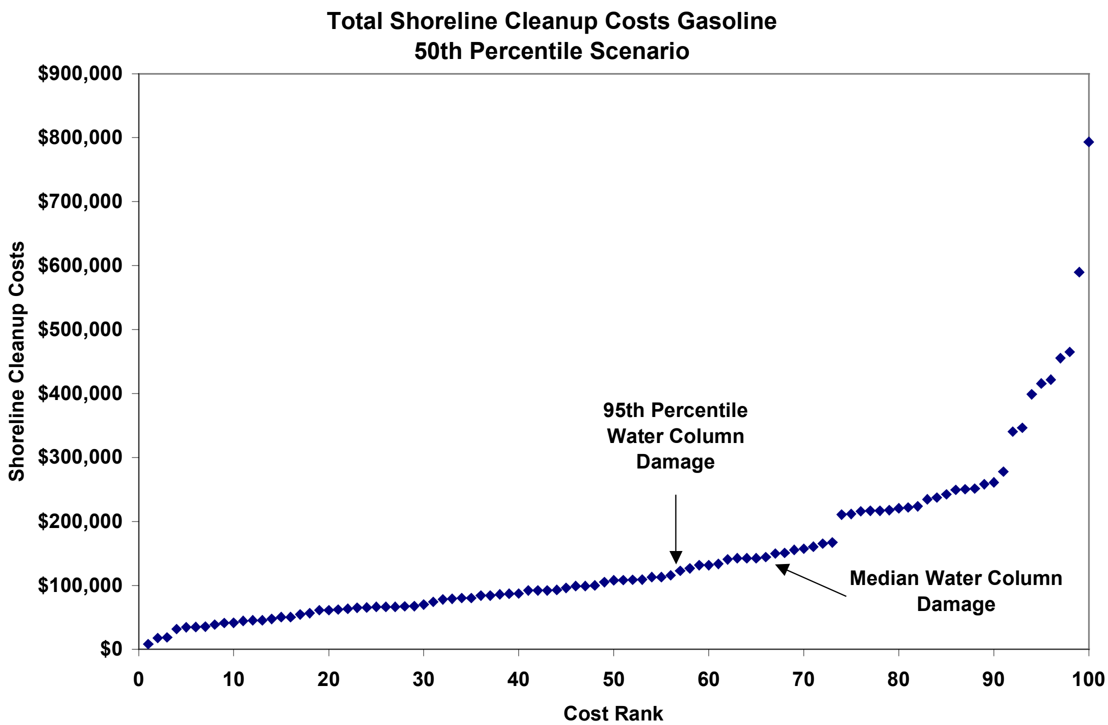
Since the shorelines are weighted differently in terms of the per-square meter cleanup costs, the amount of each type of shoreline impacted is important in determining the costs. The areas of shoreline oiled by gasoline and the type of shoreline involved are shown in Figures 33-47.

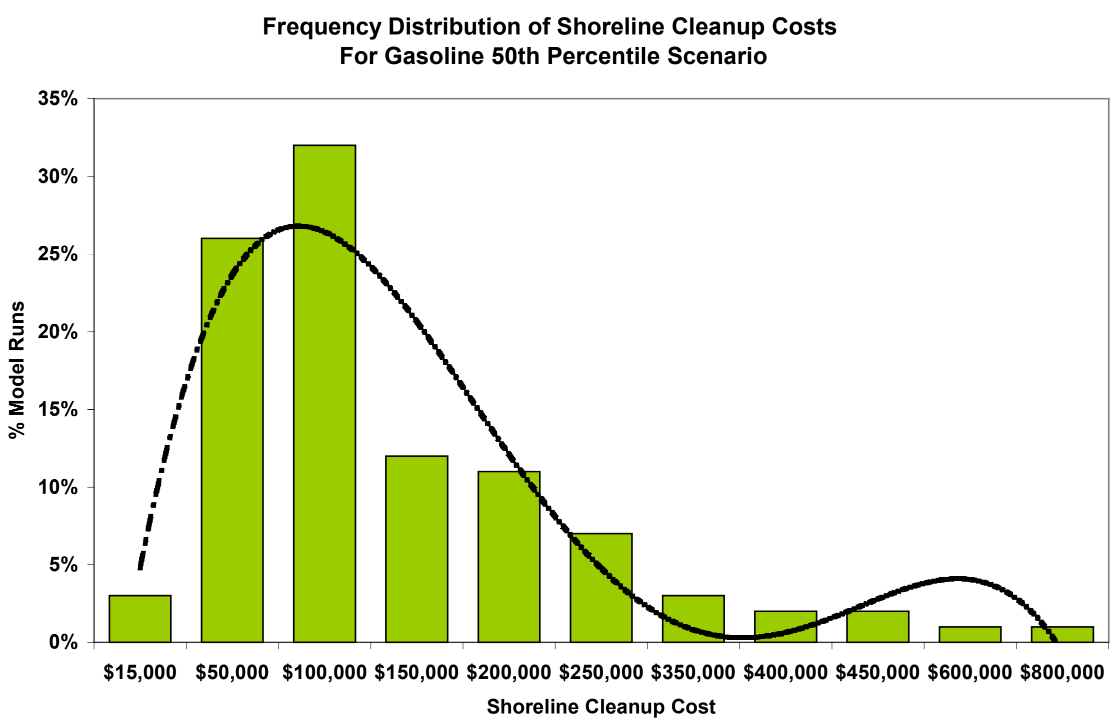
Figures 27 and 28



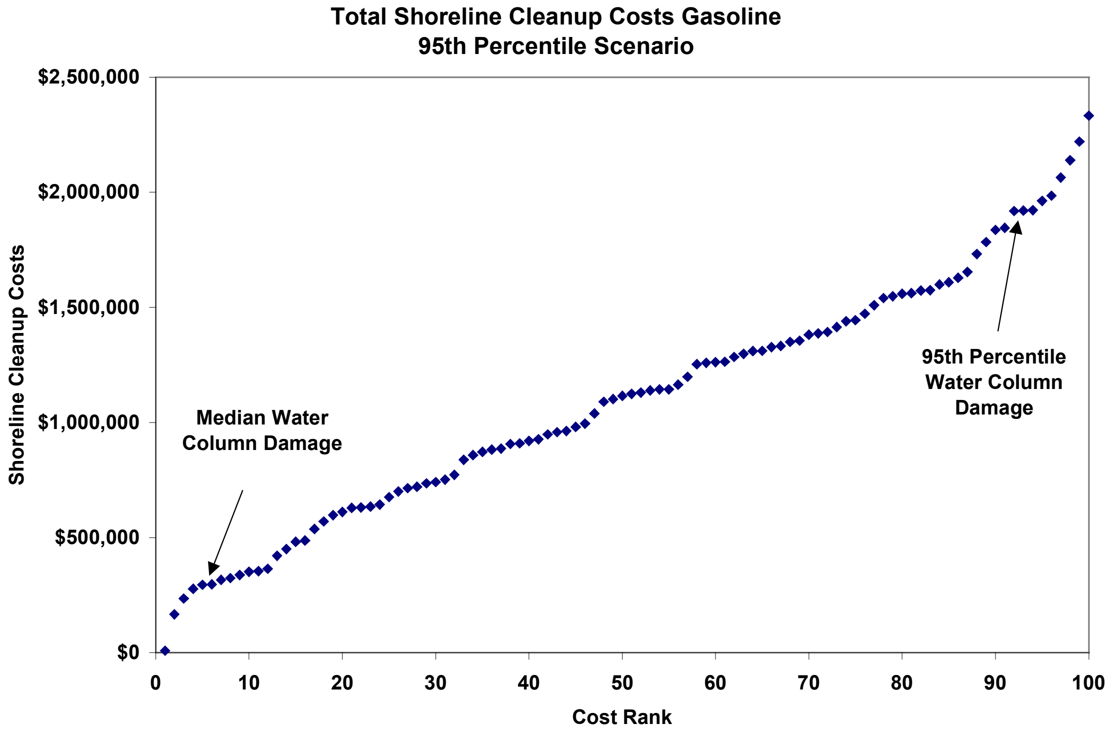


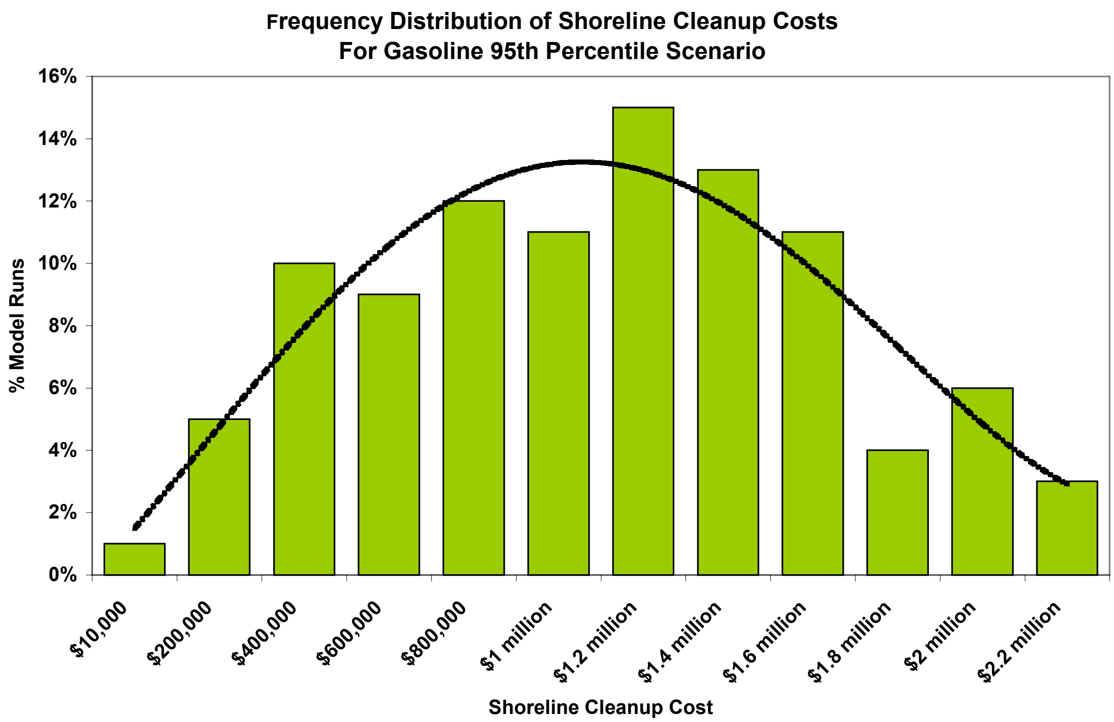
Figures 29 and 30



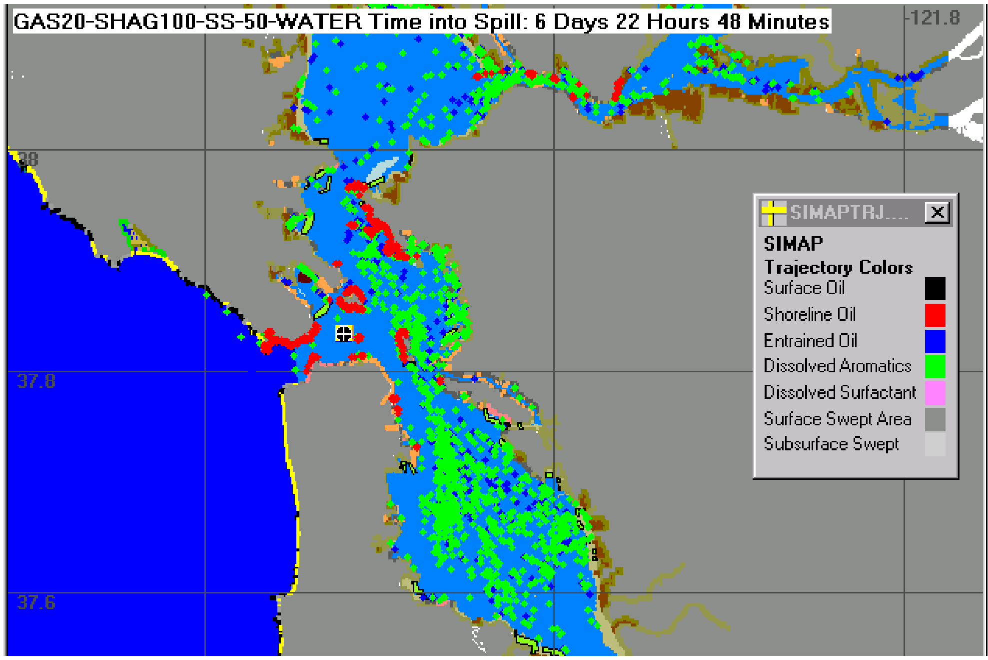


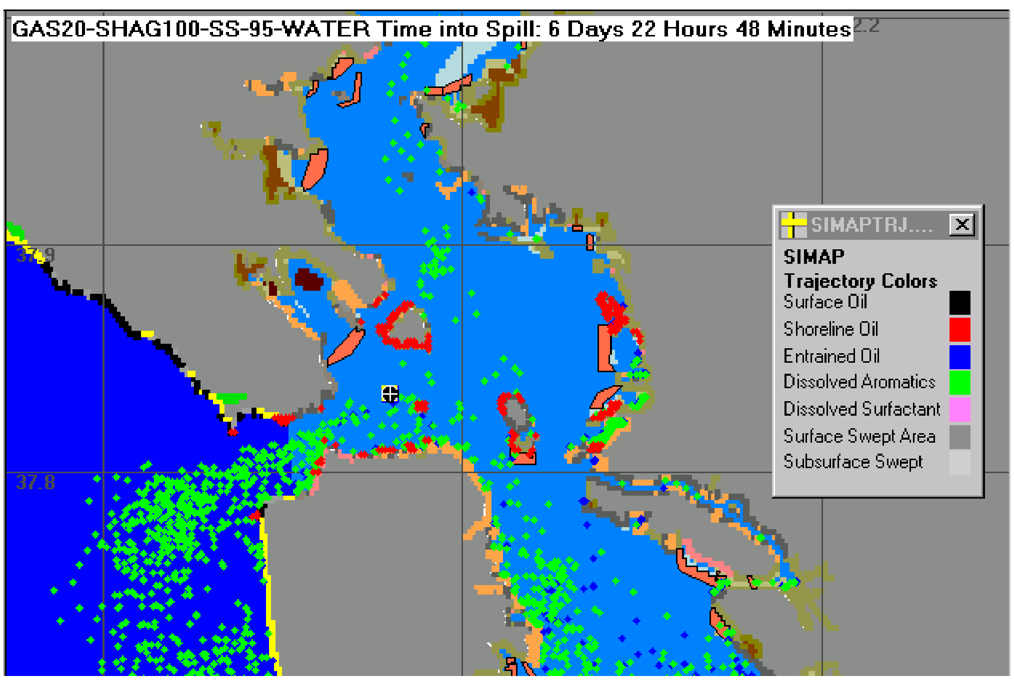
Figures 31 and 32



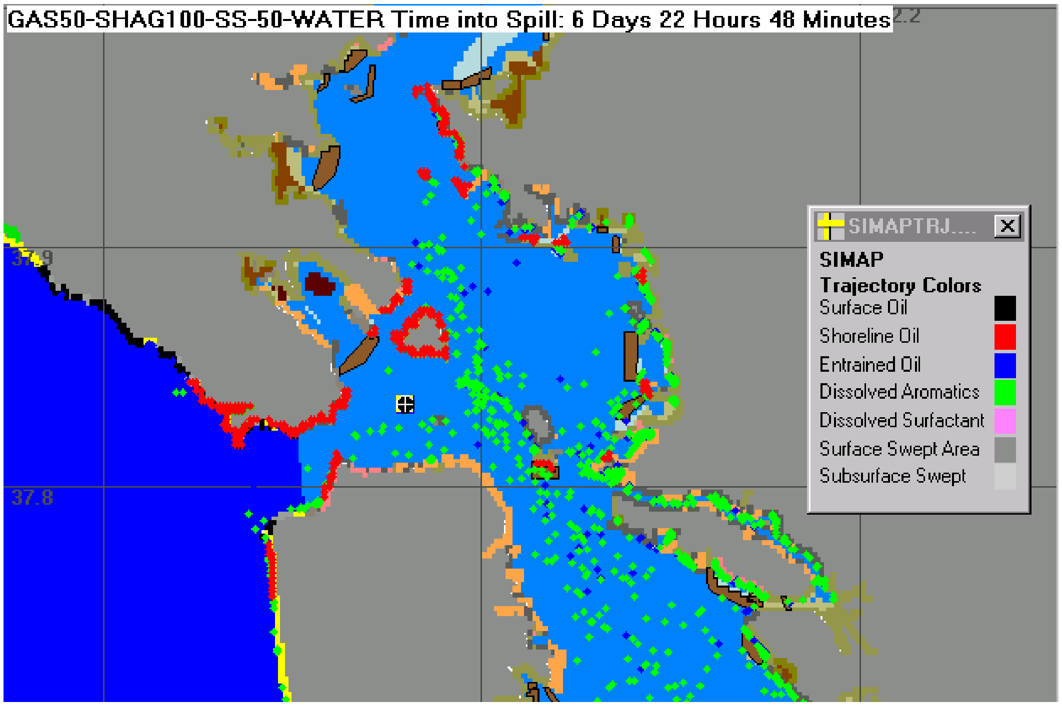


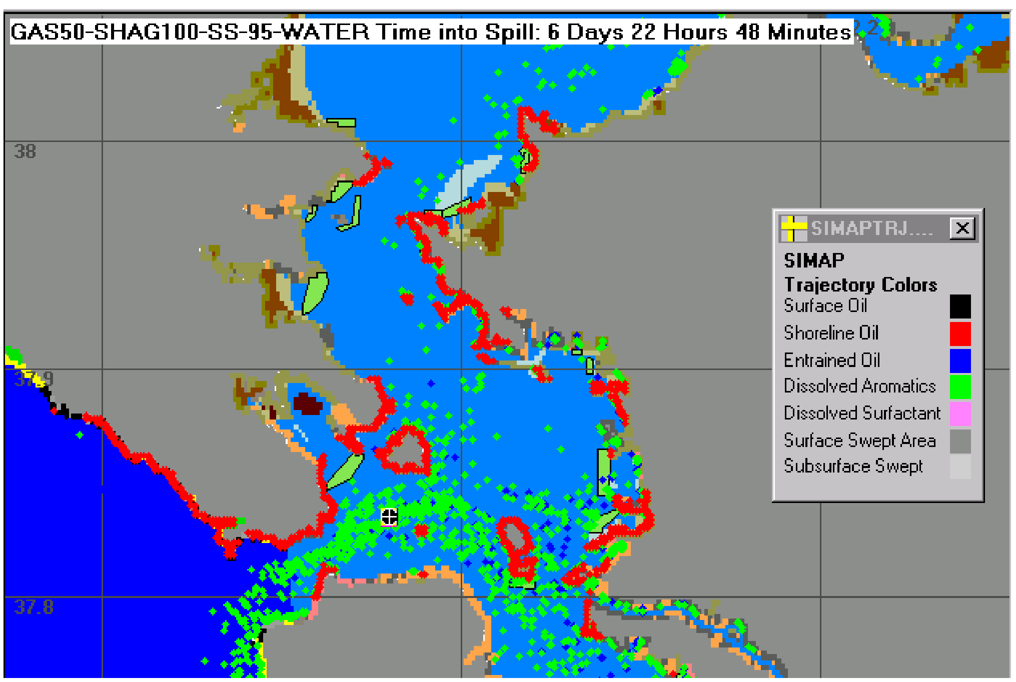
Figures 33 and 34: Shoreline Oiling for 20th Percentile Volume Gasoline Scenarios (Median Water Column Damage and Worst Water Column Damage)



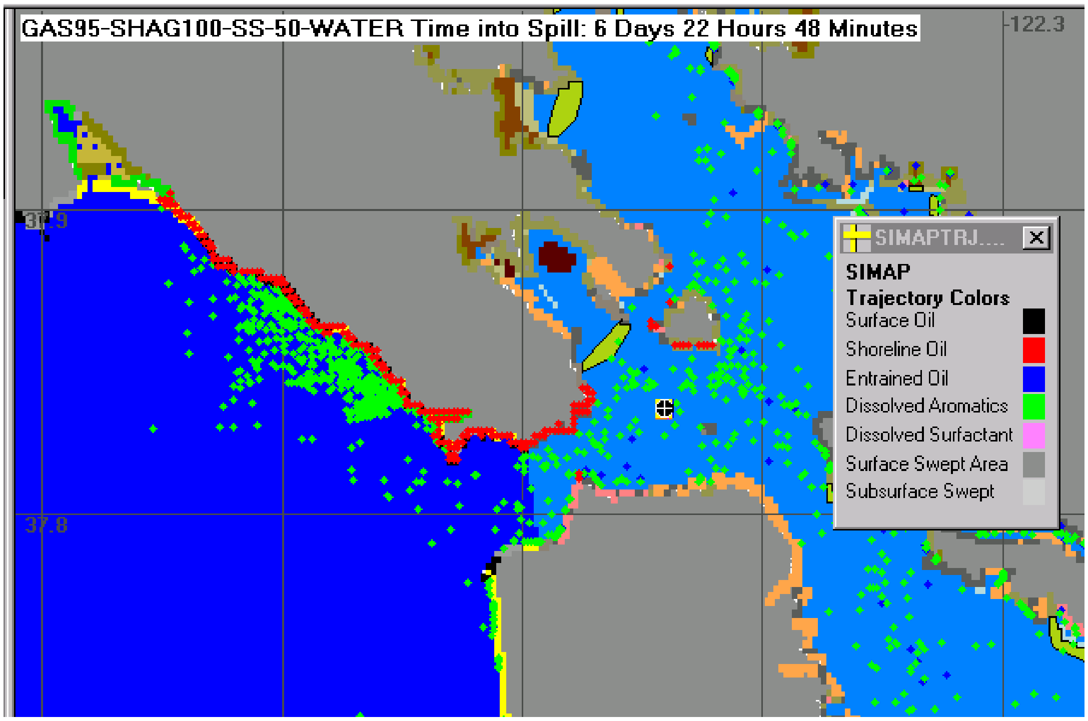


Figures 35 and 36: Shoreline Oiling for 50th Percentile Volume Gasoline Scenarios (Median Water Column Damage and Worst Water Column Damage)





Figures 37 and 38: Shoreline Oiling for 95th Percentile Volume Gasoline Scenarios (Median Water Column Damage and Worst Water Column Damage)



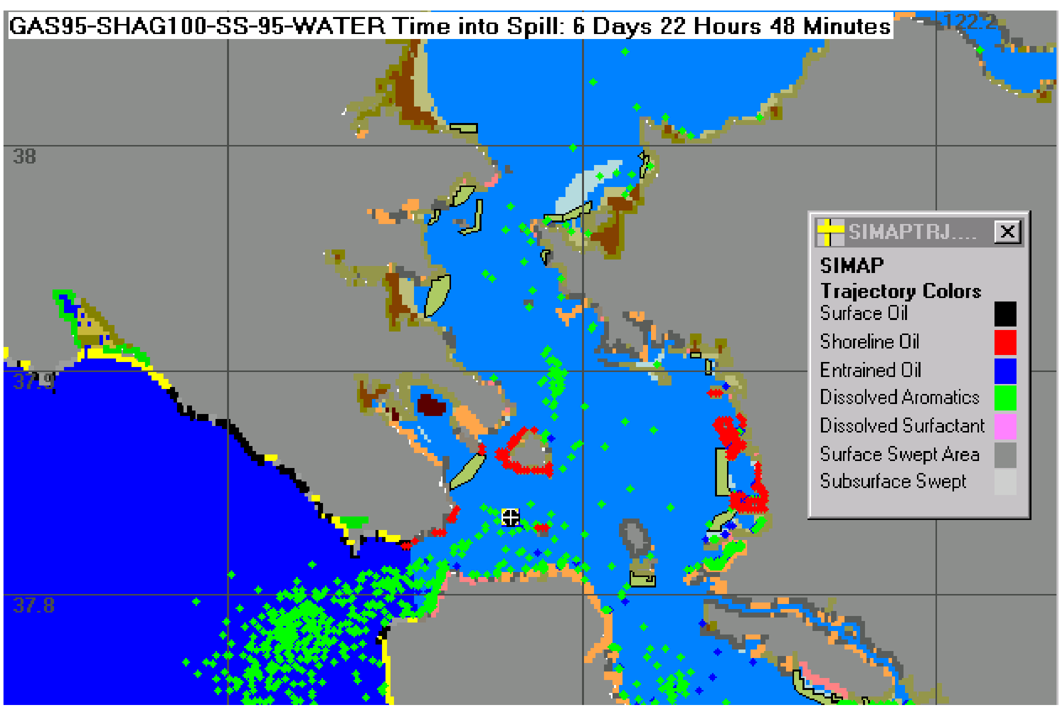


Figure 39: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Gasoline 20th Percentile Scenario

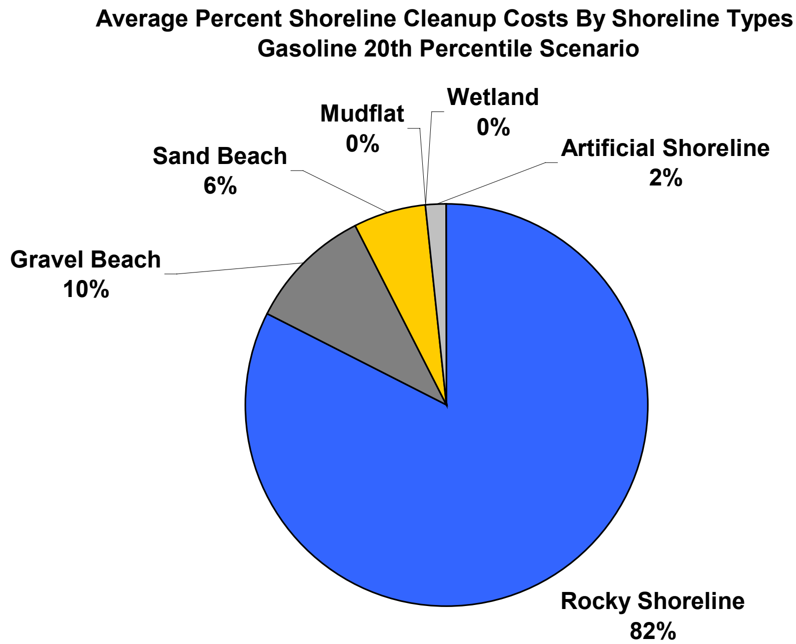


Figure 40: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Gasoline 50th Percentile Scenario

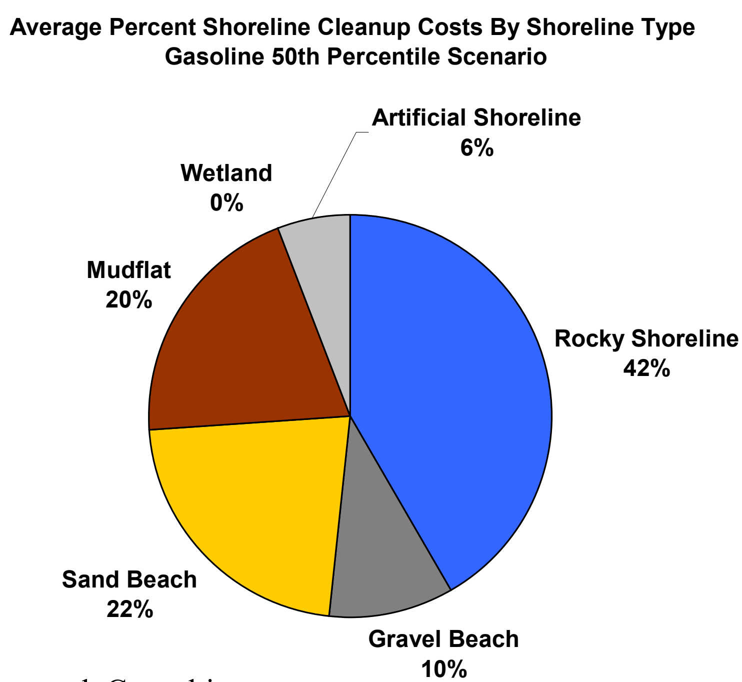
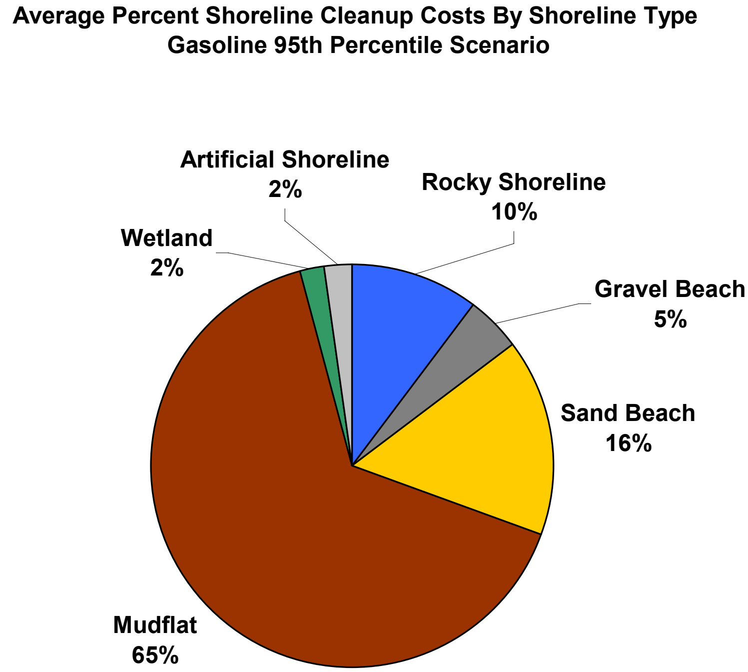
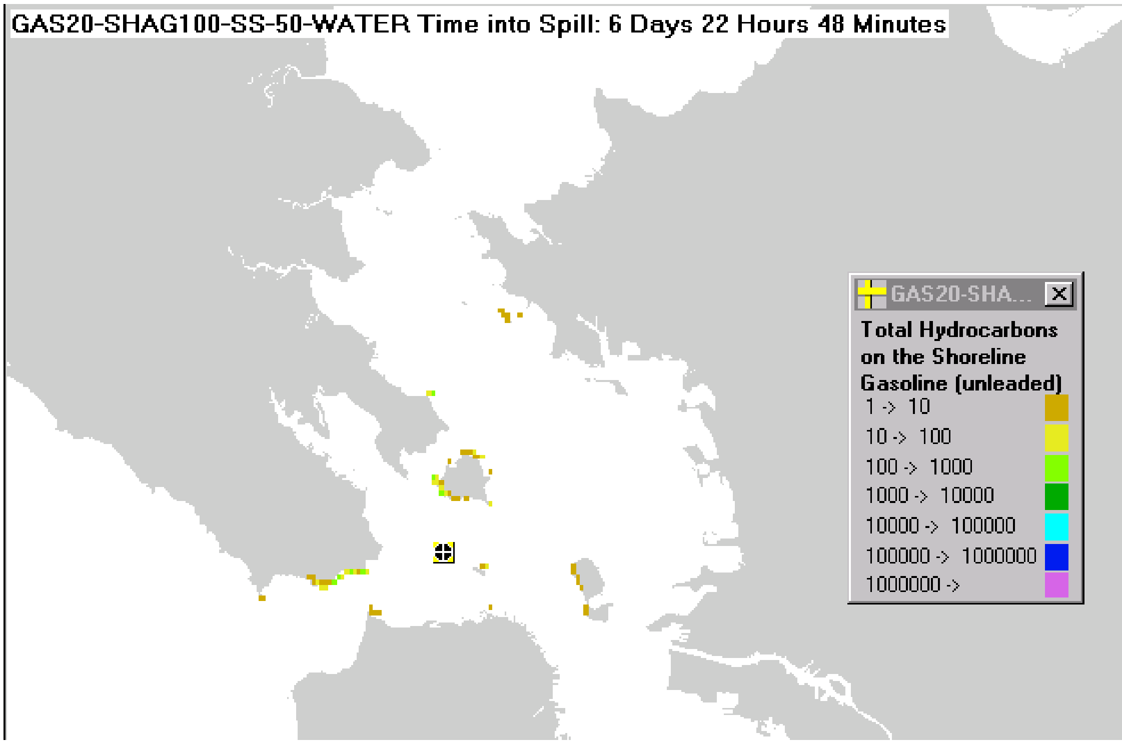
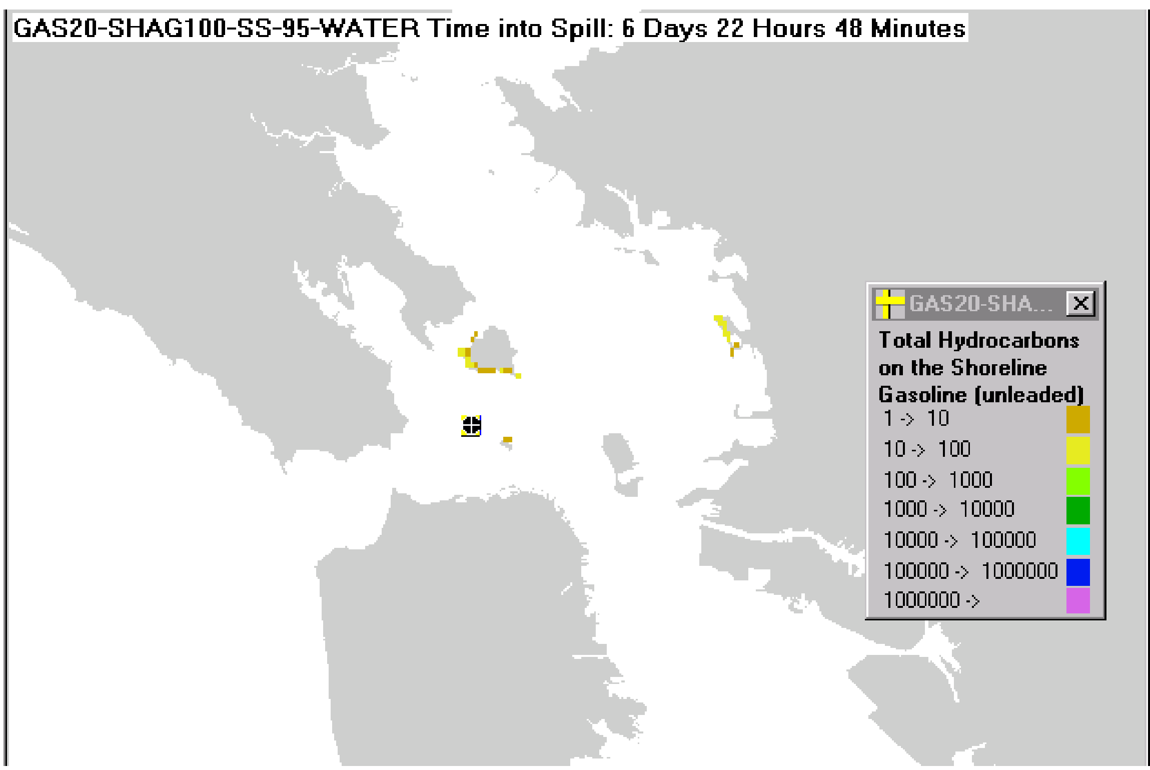


Figure 41: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Gasoline 95th Percentile Scenario

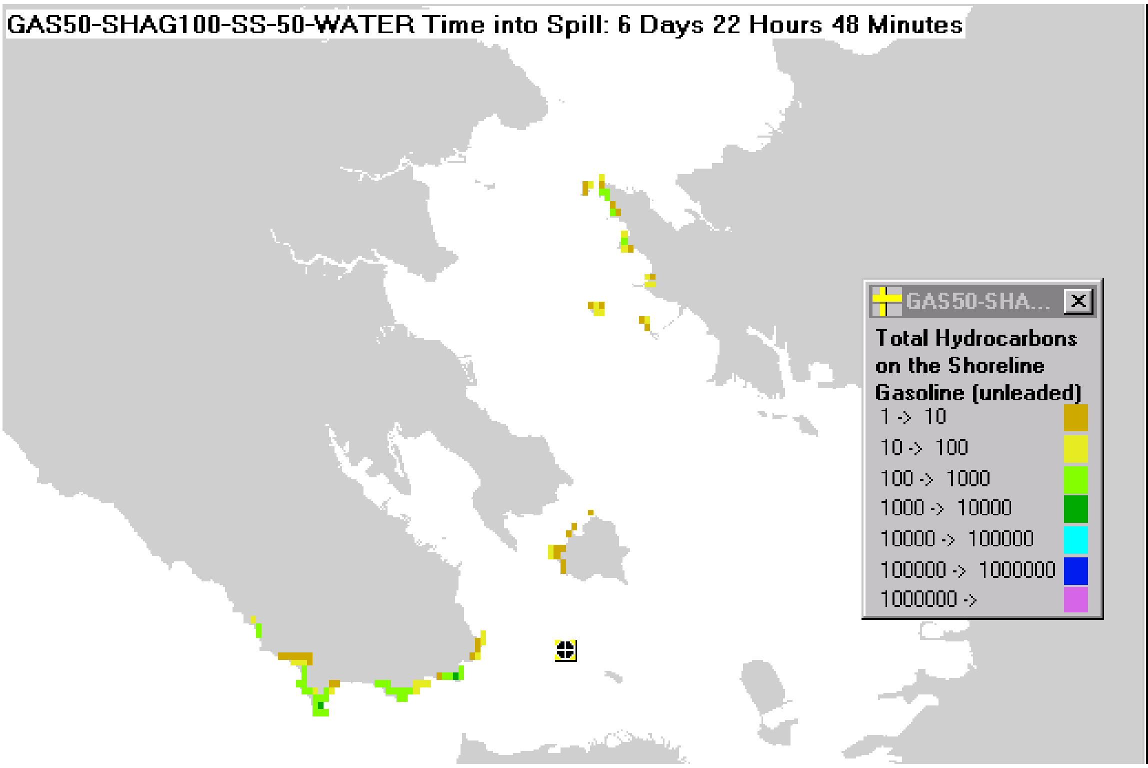


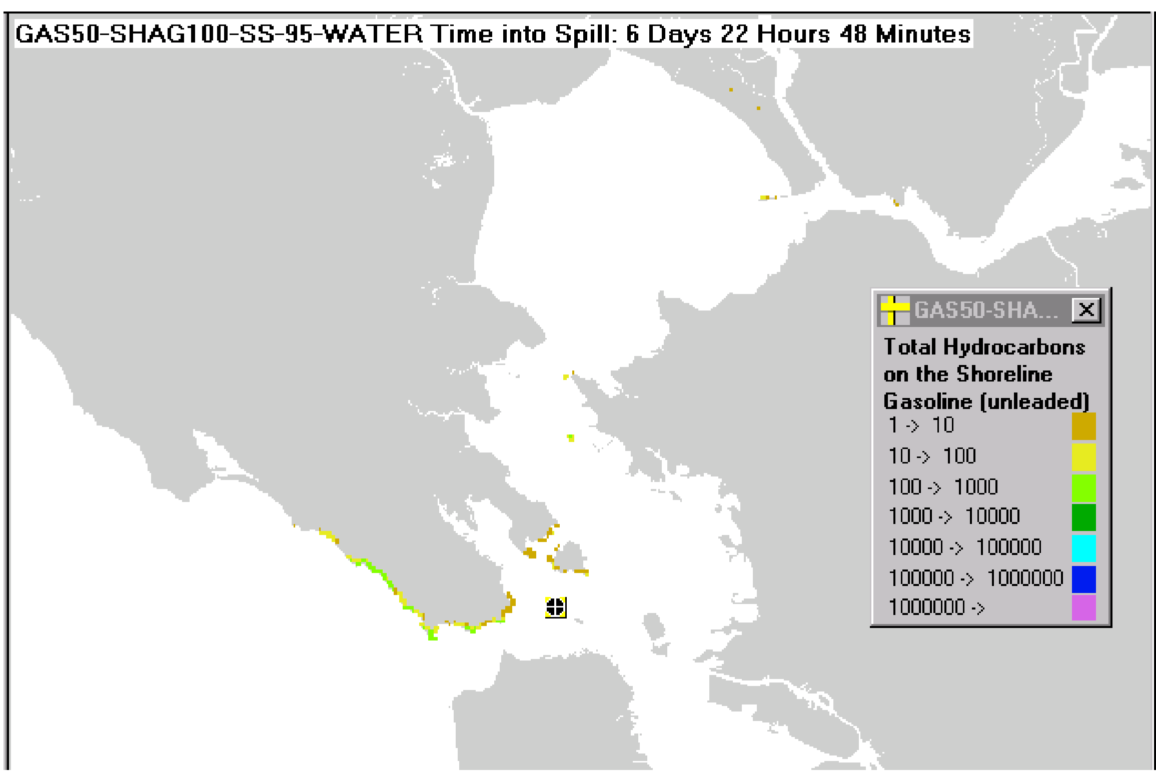
Figures 42 and 43: Shoreline Oiling Degree (g oil/m2) For Gasoline 20th Percentile Volumes (Median and Worst Water Column Damage)



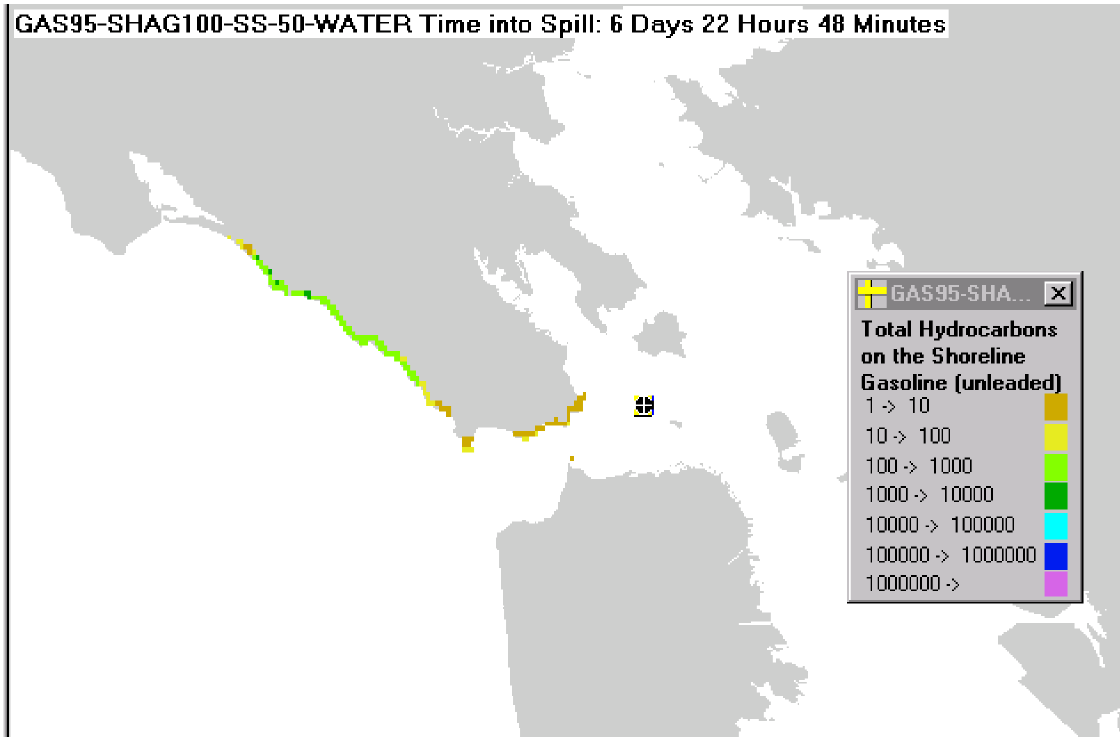


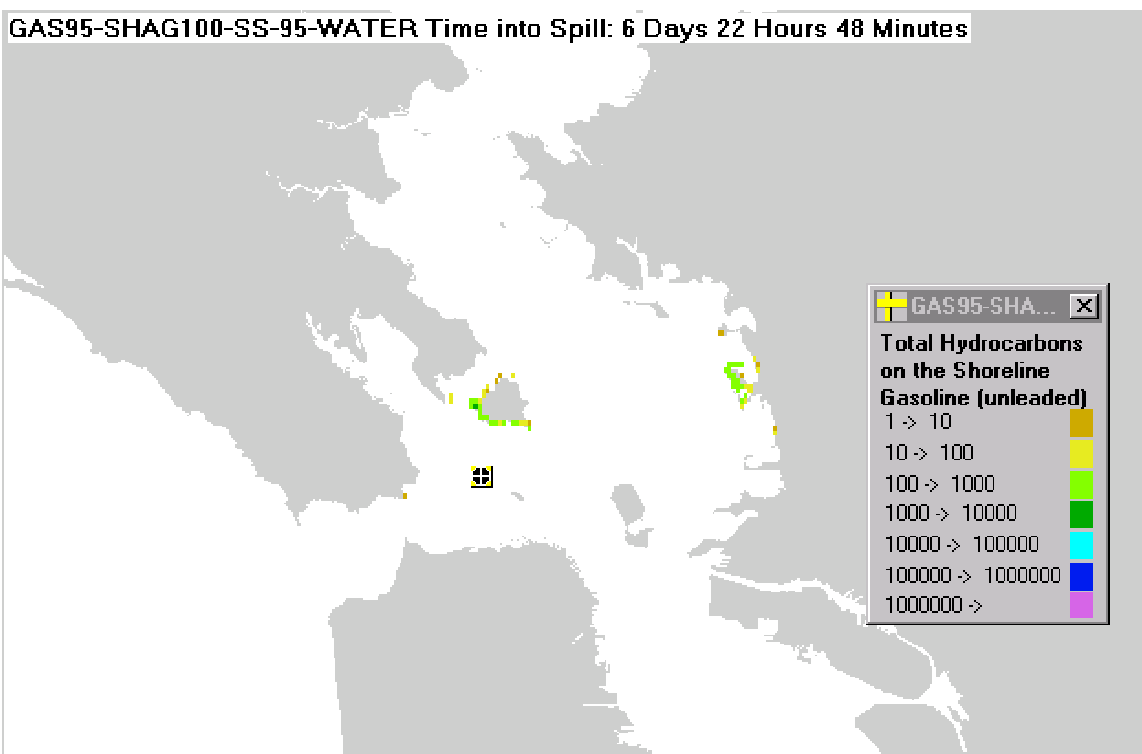
Figures 44 and 45: Shoreline Oiling Degree (g oil/m2) For Gasoline 50th Percentile Volumes (Median and Worst Water Column Damage)





Figures 46 and 47: Shoreline Oiling Degree (g oil/m2) For Gasoline 20th Percentile Volumes (Median and Worst Water Column Damage)

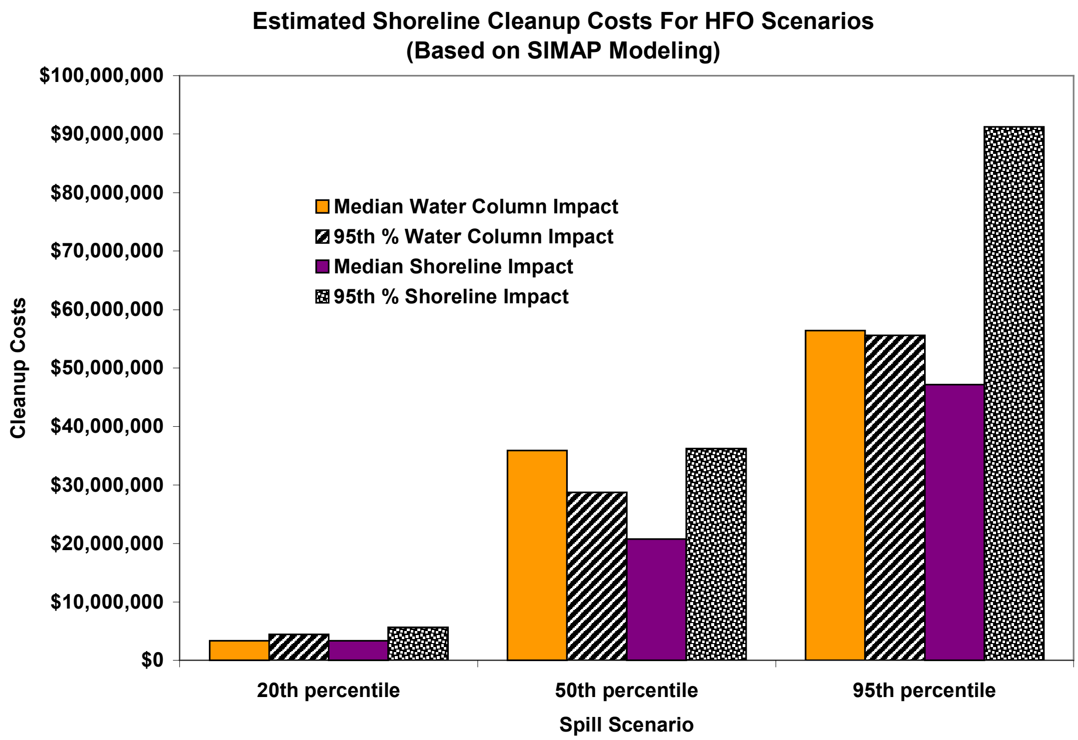




4.4 Shoreline Cleanup For Heavy Fuel Oil Scenarios

The shoreline cleanup costs for the heavy fuel oil (HFO) spill scenarios based on median and worst (95^{th} percentile) water column and shoreline cost impact are compared in Figure 48.

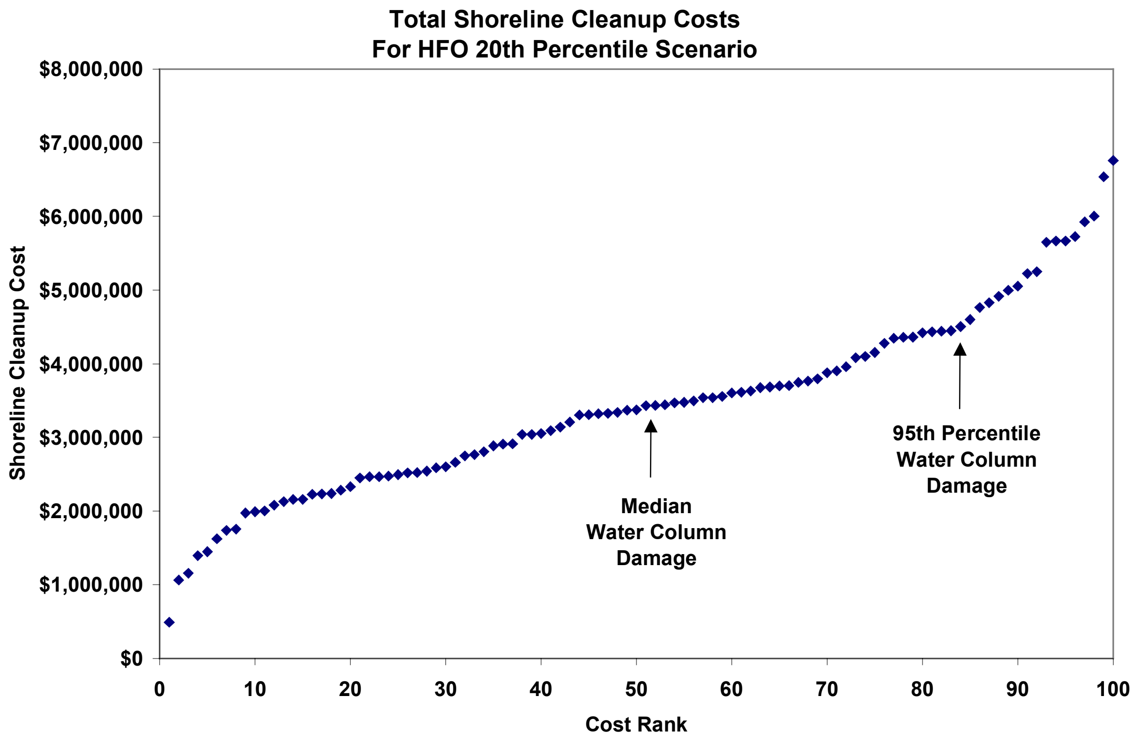
Figure 48

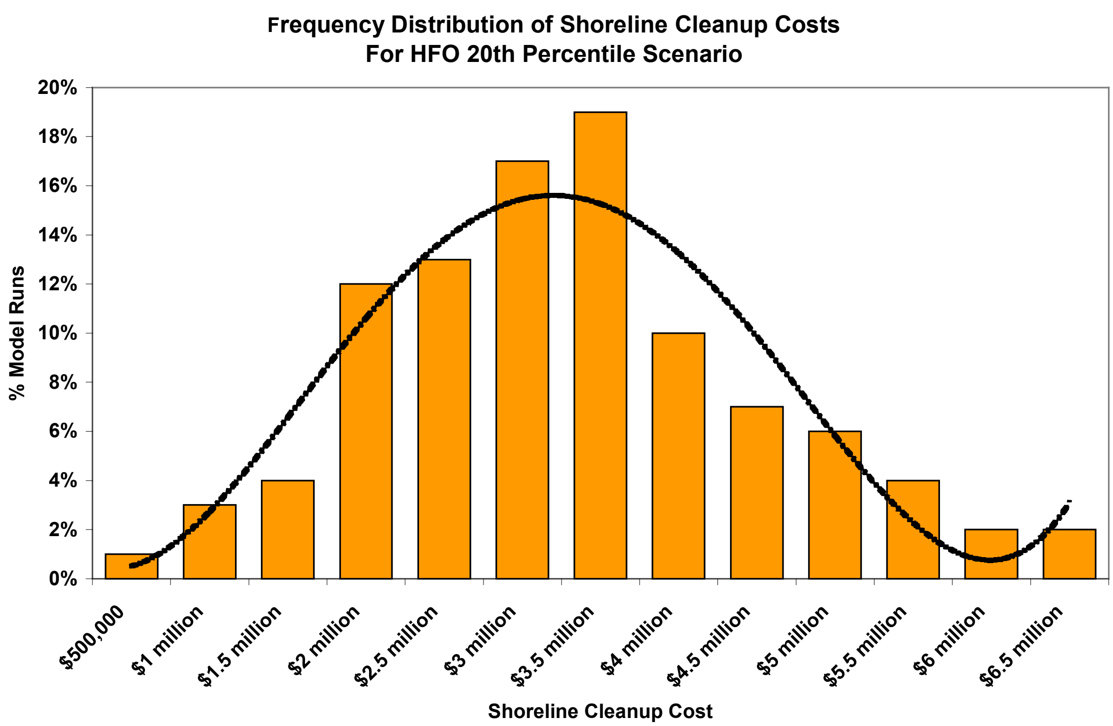


The percentile ranks are based on cost modeling for 100 separate SIMAP spill runs, each of which has a slightly different impact on the shoreline areas of the bay. Figures 49 and 50 show the range of costs for the SIMAP runs for the 20^{th} percentile HFO *volume* scenario (25,000 gallons spilled). Figures 51 and 52 show the range of costs for the SIMAP runs for the 50^{th} percentile HFO *volume* scenario (100,000 gallons spilled). Figures 53 and 54 show the range of costs for the SIMAP runs for the 95^{th} percentile gasoline *volume* scenario (410,000 gallons spilled).

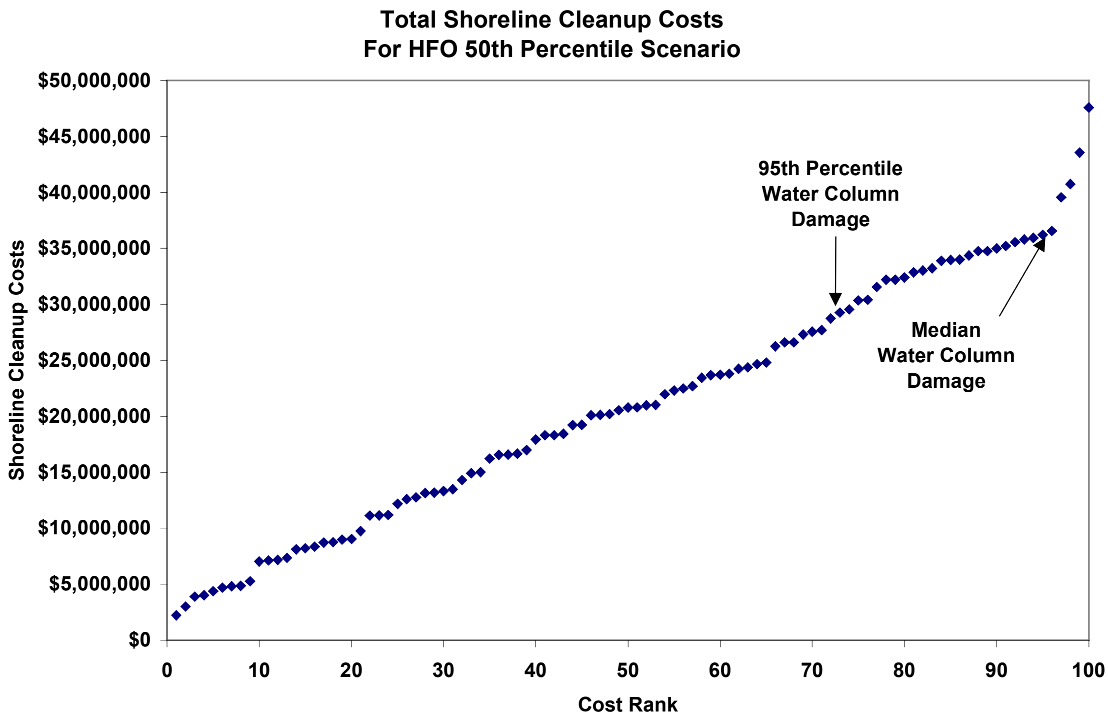
Since the shorelines are weighted differently in terms of the per-square meter cleanup costs, the amount of each type of shoreline impacted is important in determining the costs. The areas of shoreline oiled by HFO and the type of shoreline involved are shown in Figures 55-69.

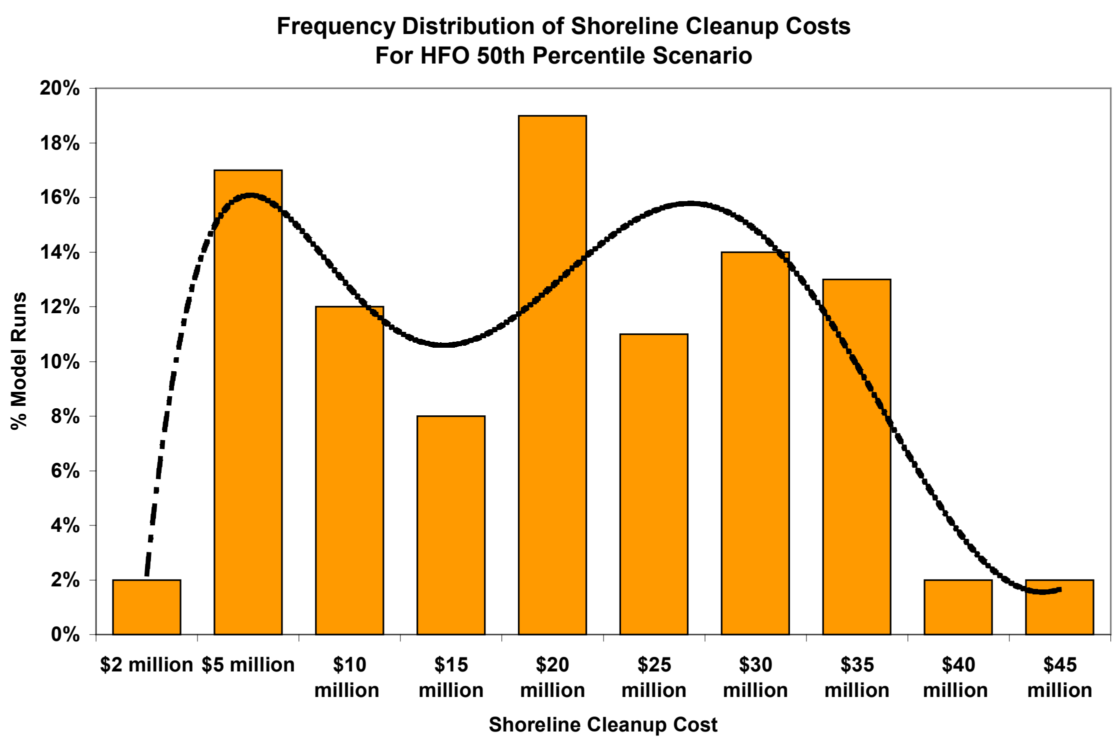
Figures 49 and 50



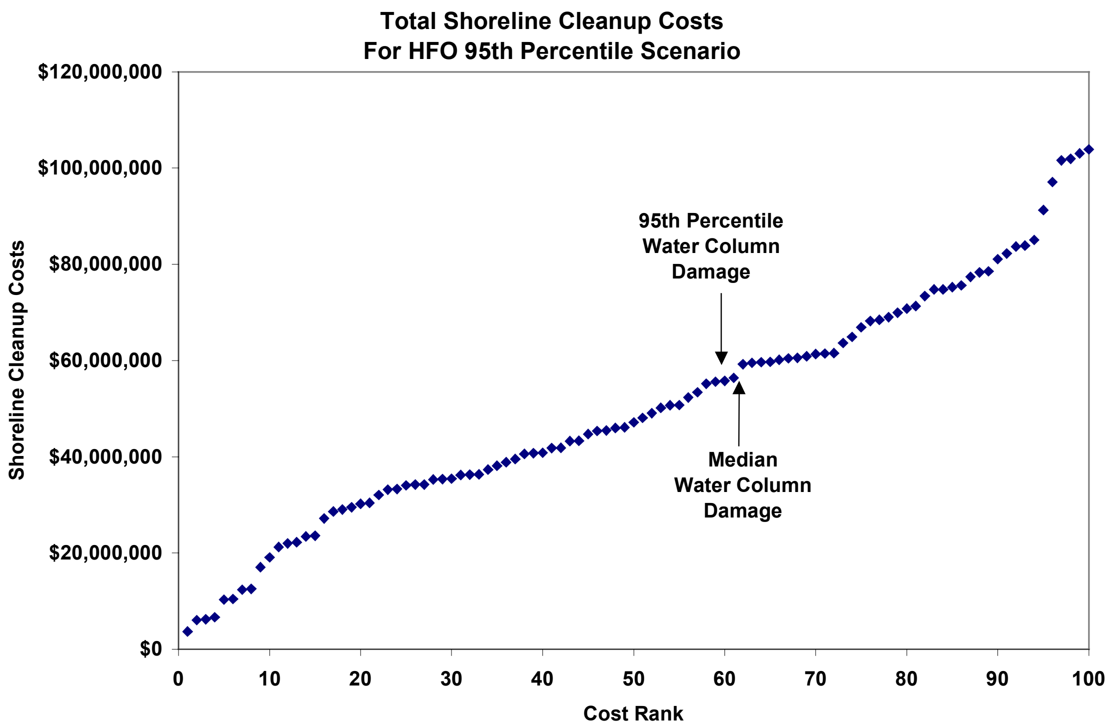


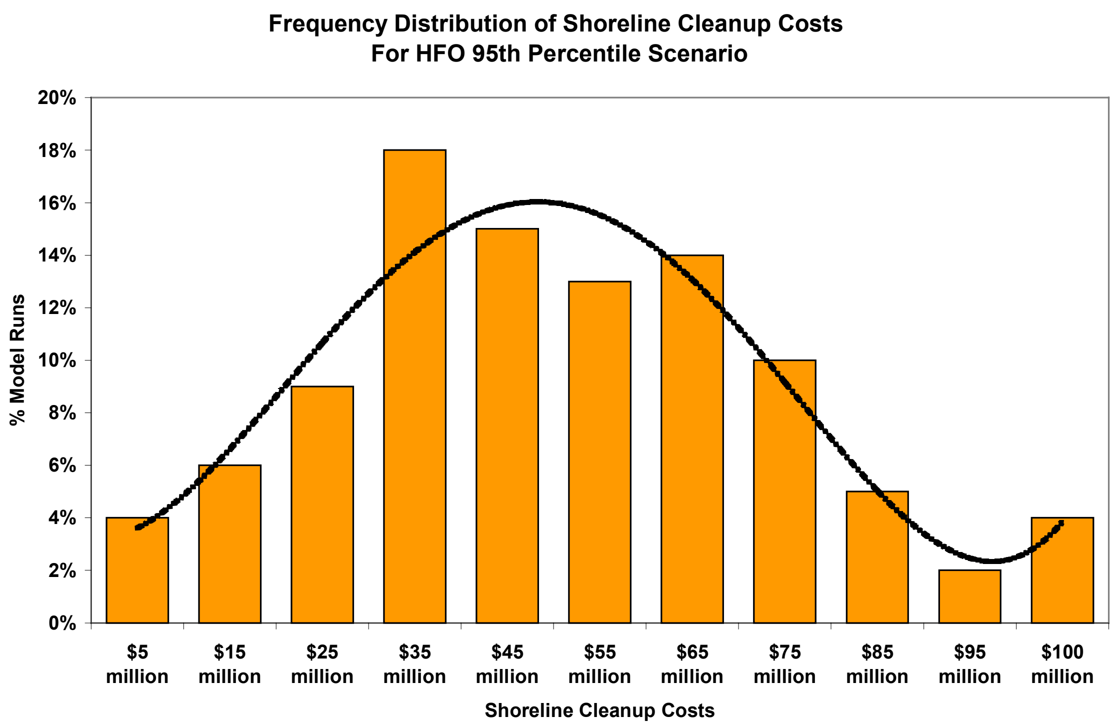
Figures 51 and 52



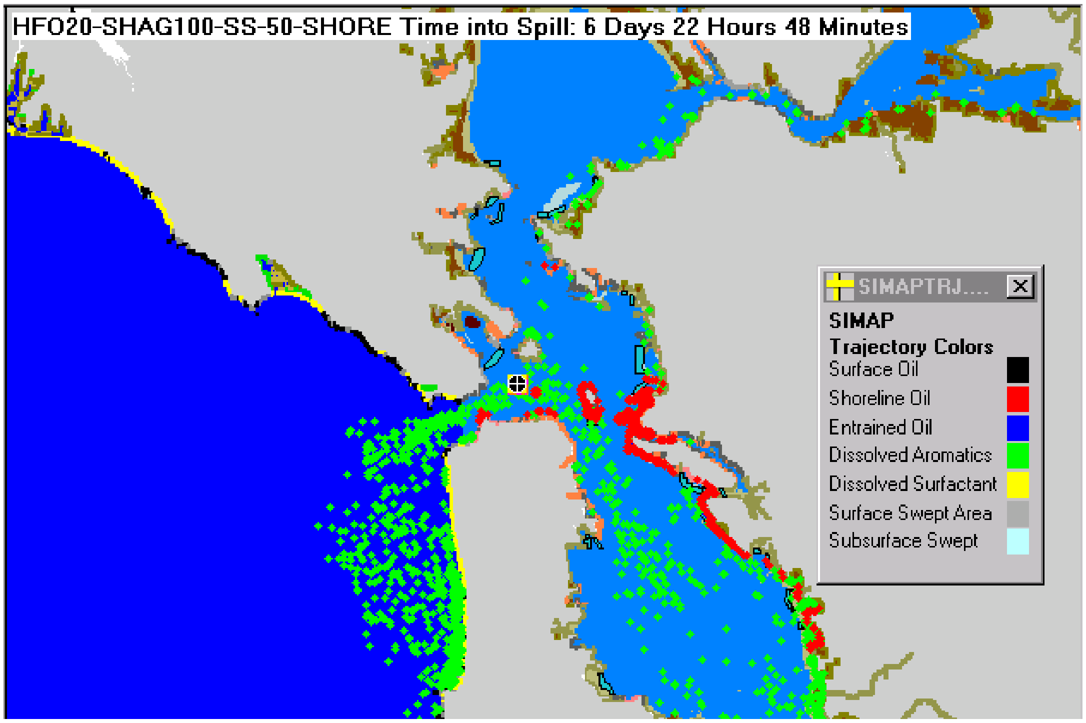


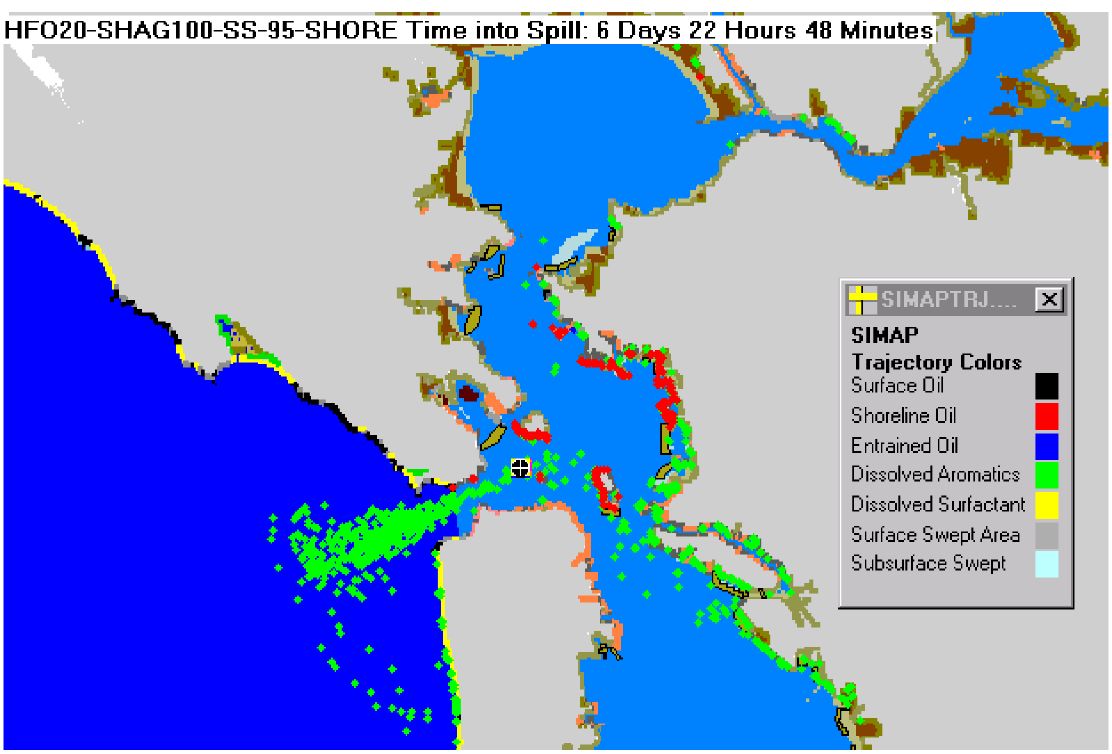
Figures 53 and 54



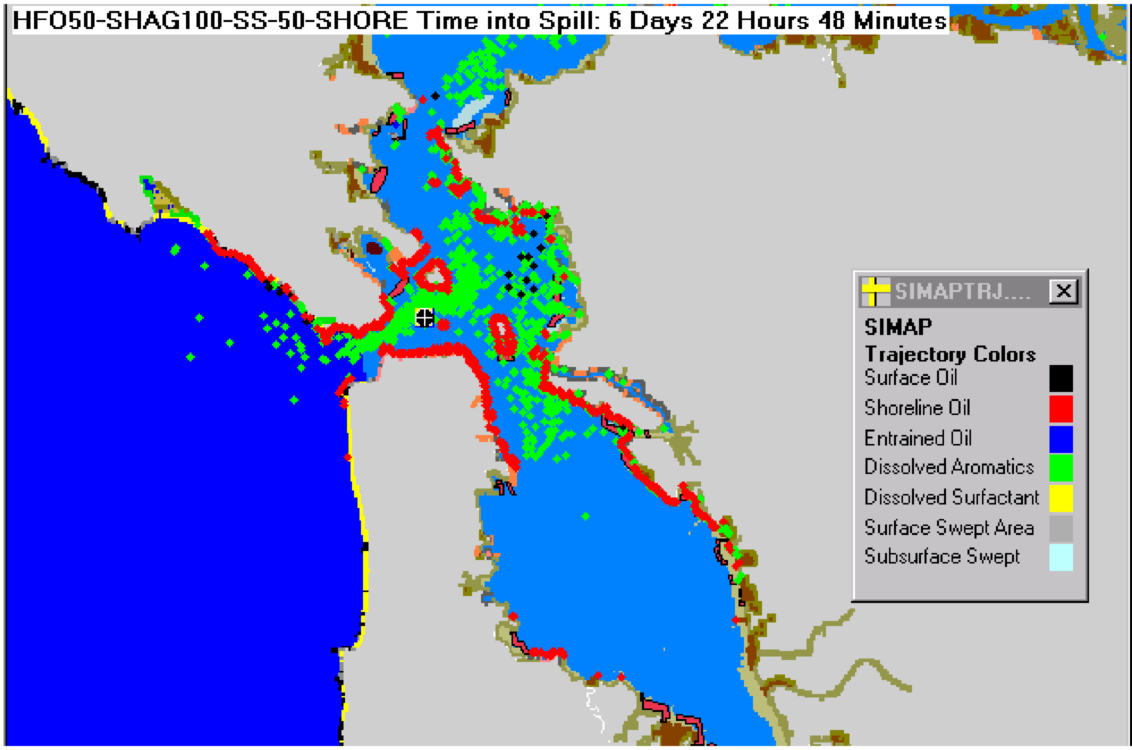


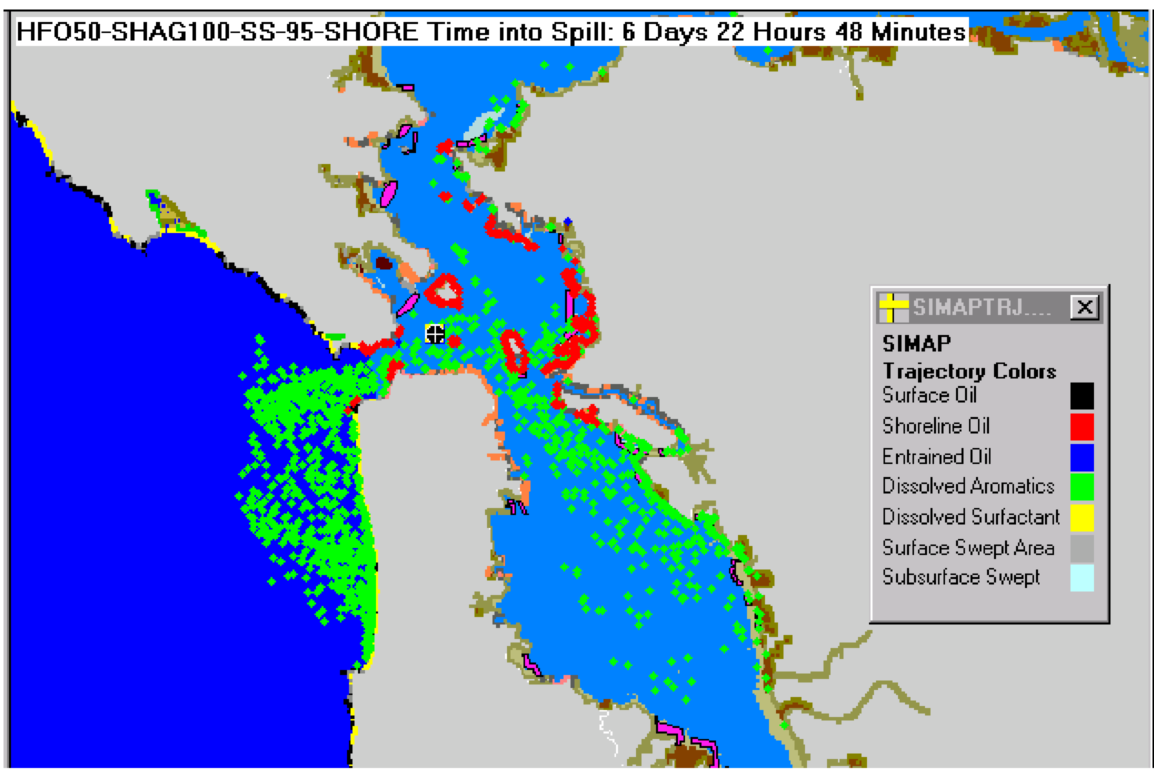
Figures 55 and 56: Oiling for 20th Percentile Volume HFO Scenarios (Median Shoreline Damage and Worst Shoreline Damage) with shoreline oiling in red



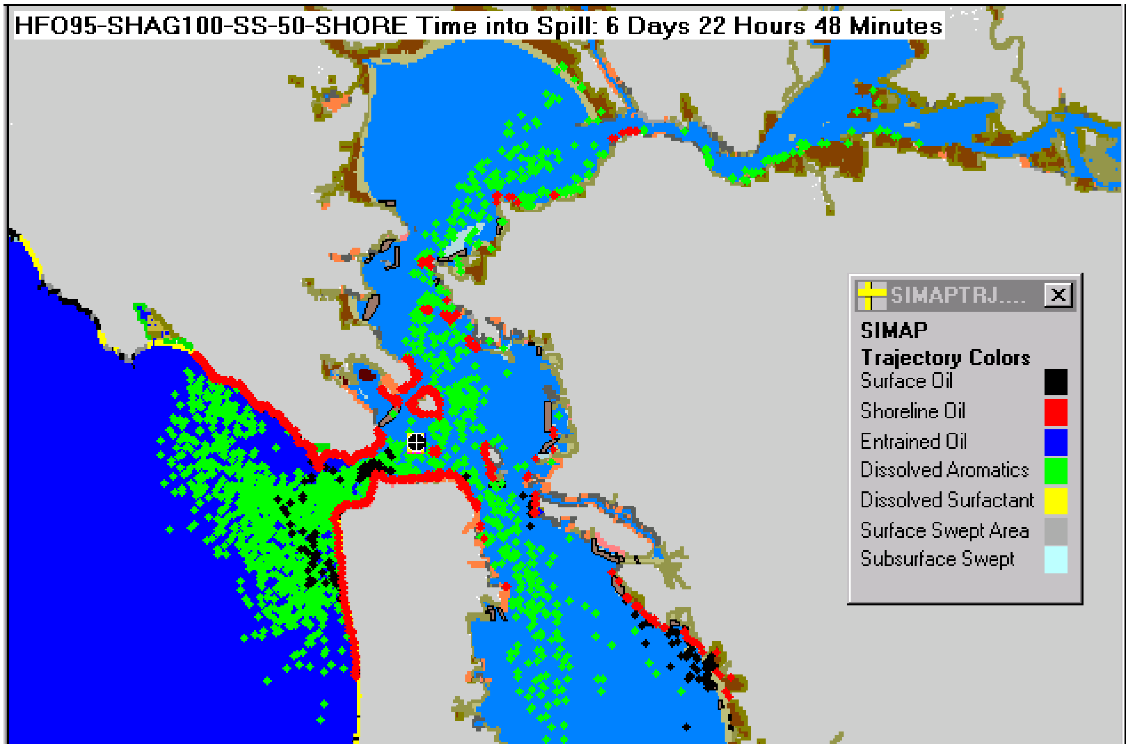


Figures 57 and 58: Oiling for 50th Percentile Volume HFO Scenarios (Median Shoreline Damage and Worst Shoreline Damage) with shoreline oiling in red





Figures 59 and 60: Oiling for 95th Percentile Volume HFO Scenarios (Median Shoreline Damage and Worst Shoreline Damage) with shoreline oiling in red



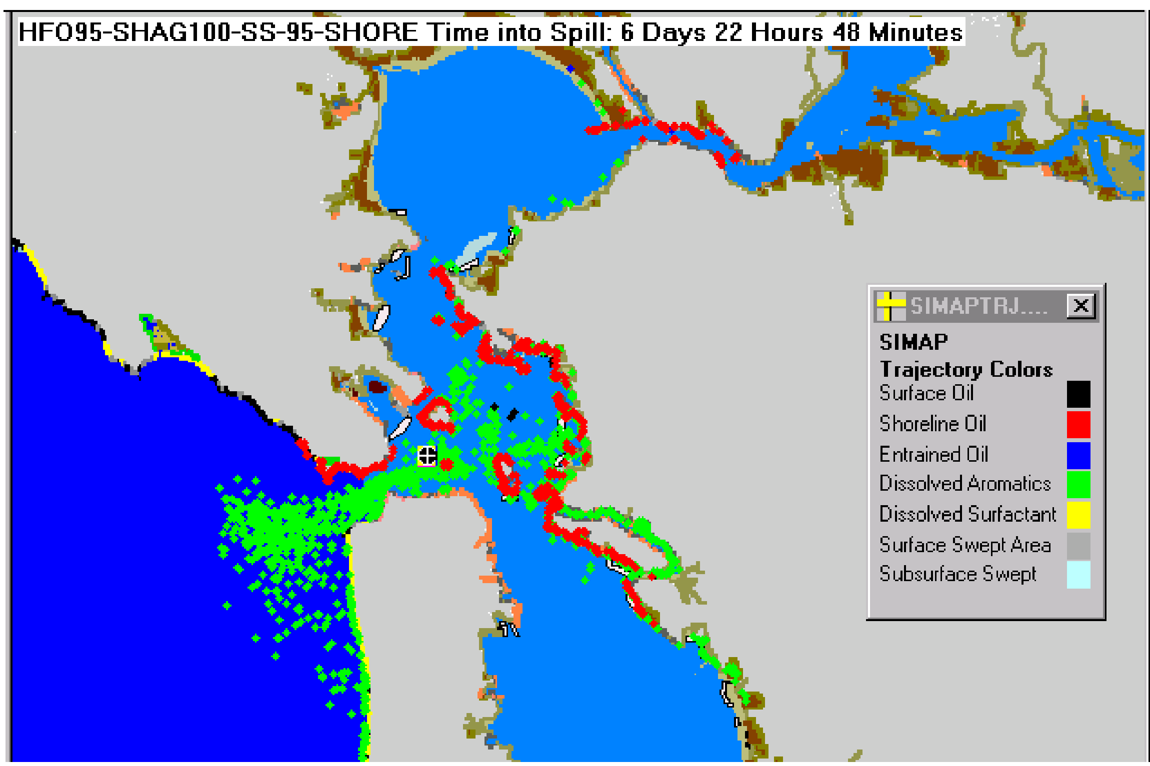


Figure 61: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): HFO 20th Percentile Scenario

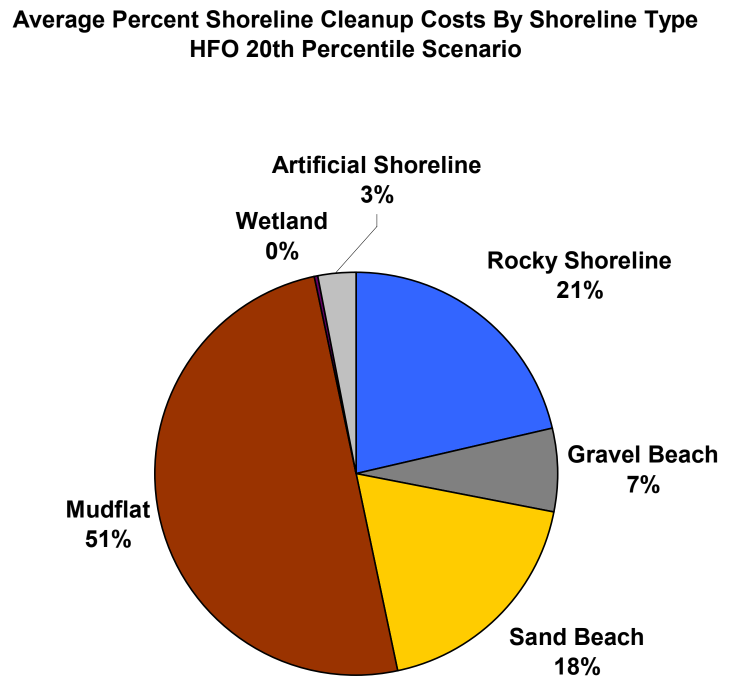


Figure 62: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): HFO 50th Percentile Scenario

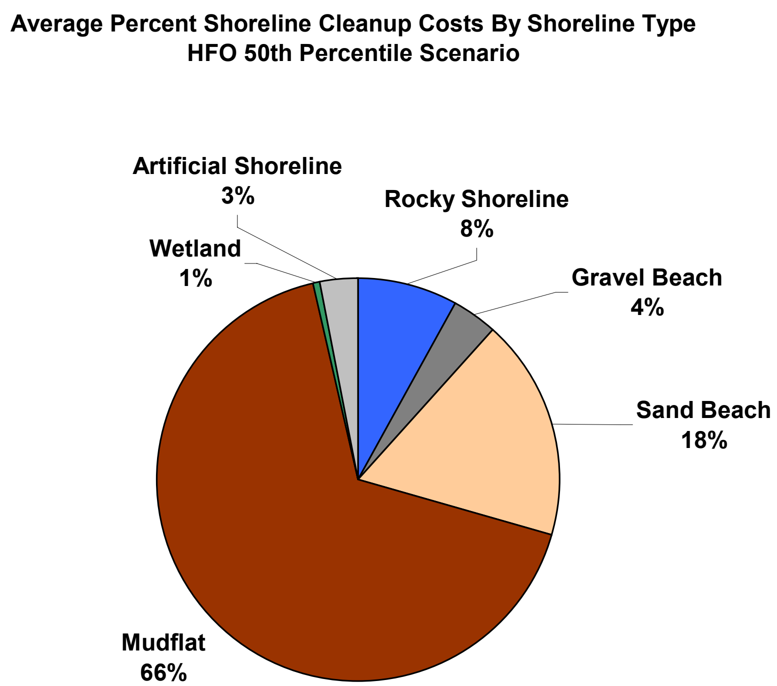
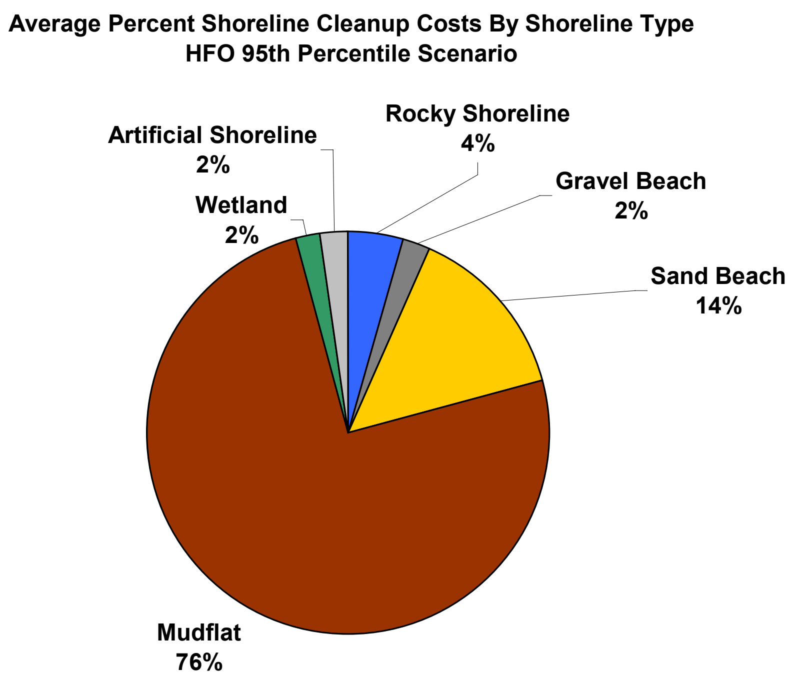
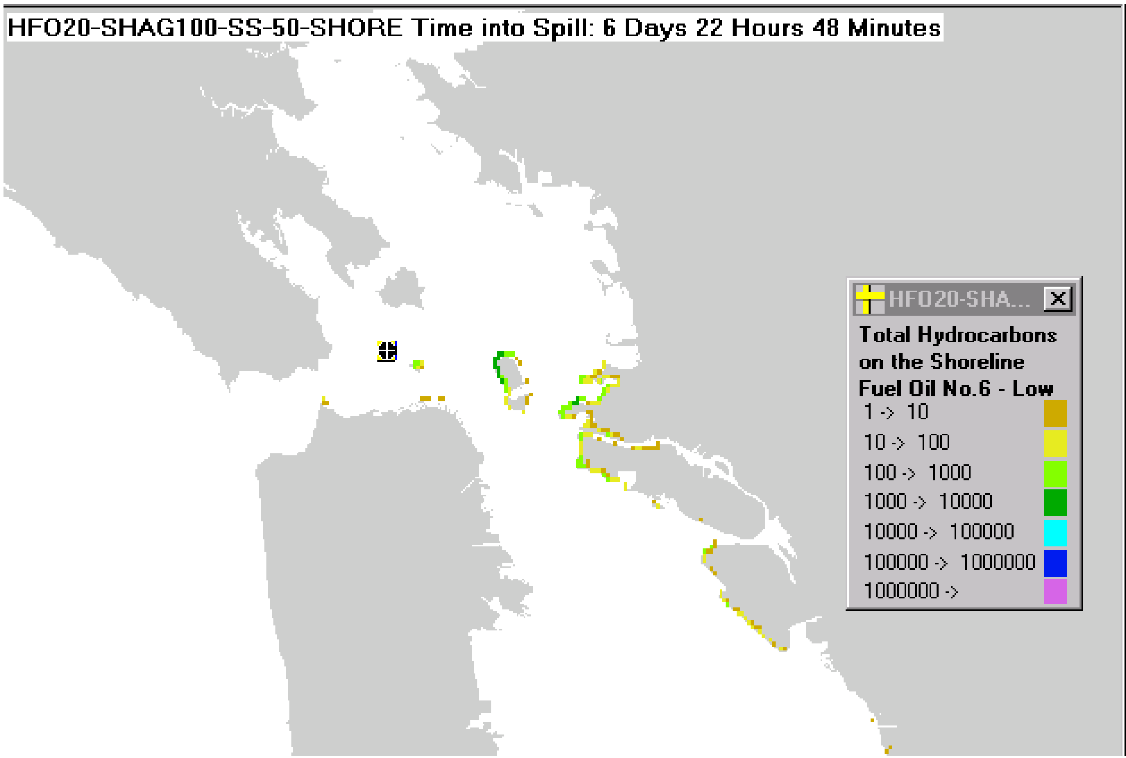
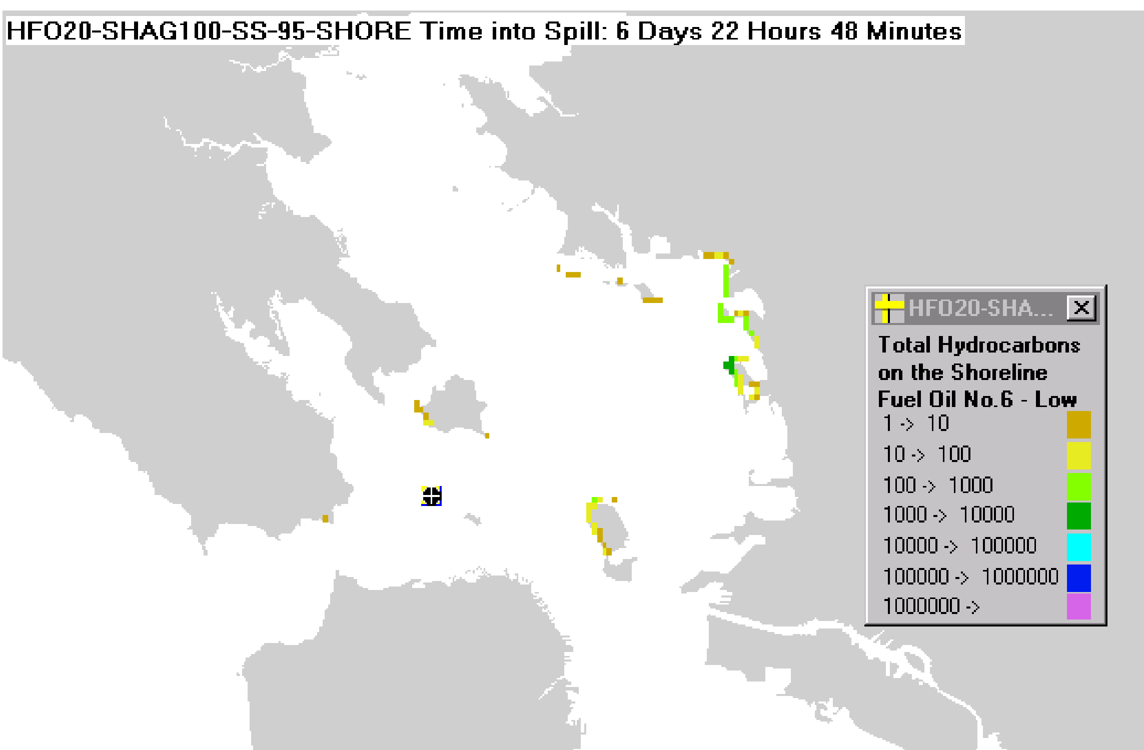


Figure 63: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): HFO 95th Percentile Scenario

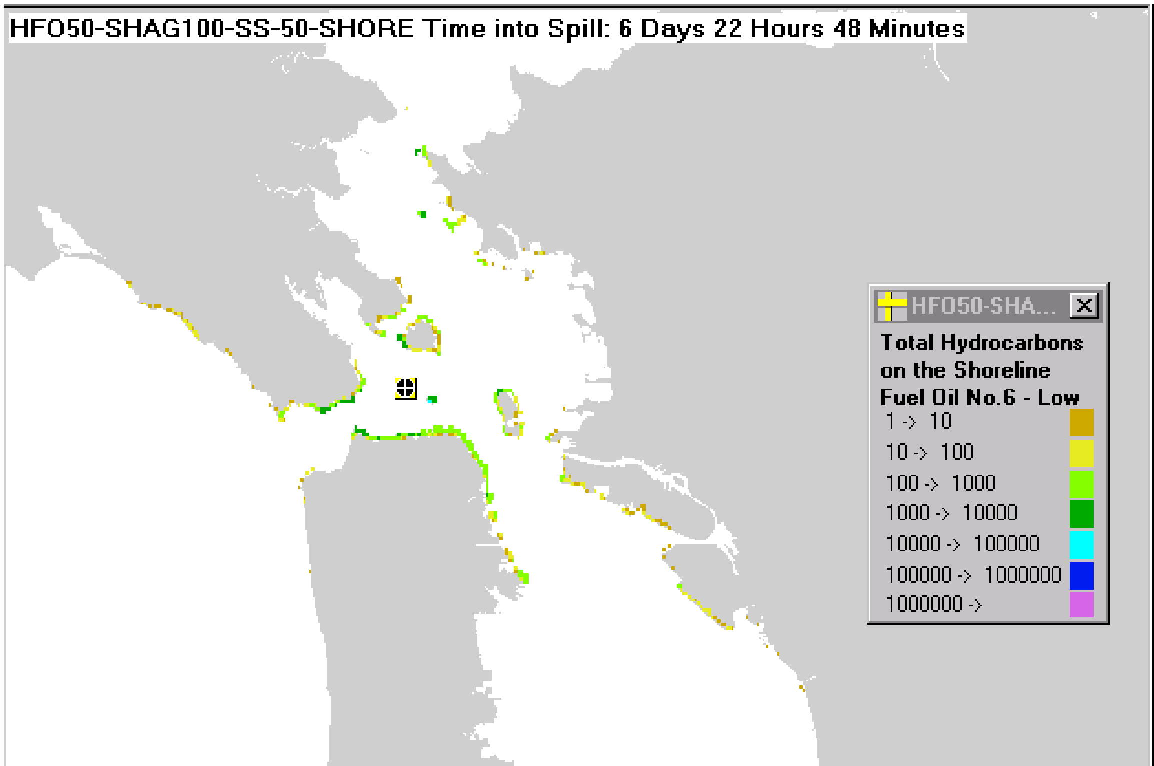


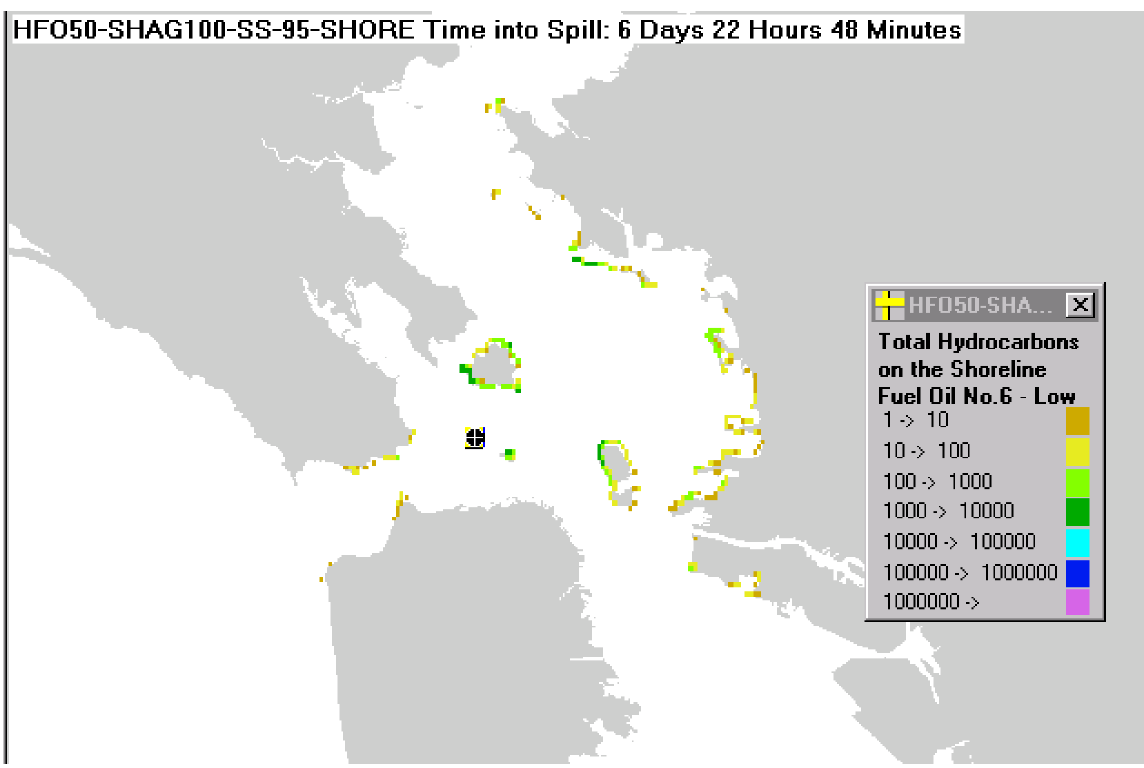
Figures 64 and 65: Shoreline Oiling Degree (g oil/m^2) For HFO 20th Percentile Volumes (Median and Worst Water Column Damage)



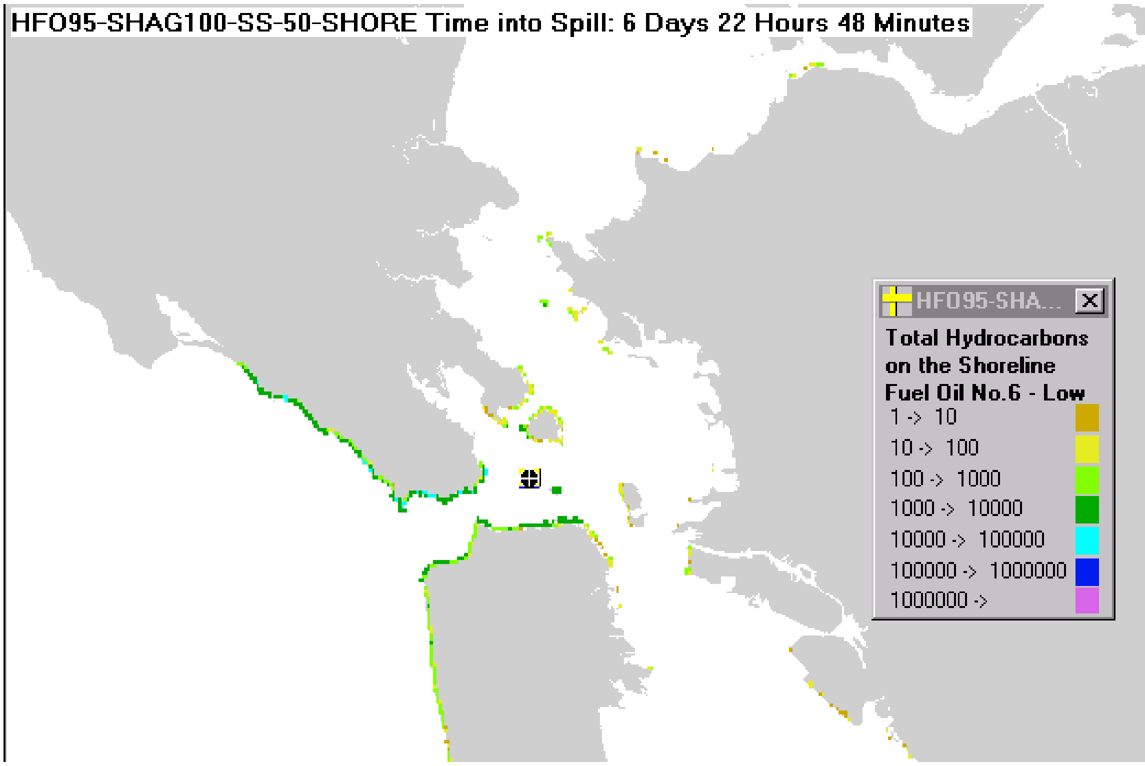


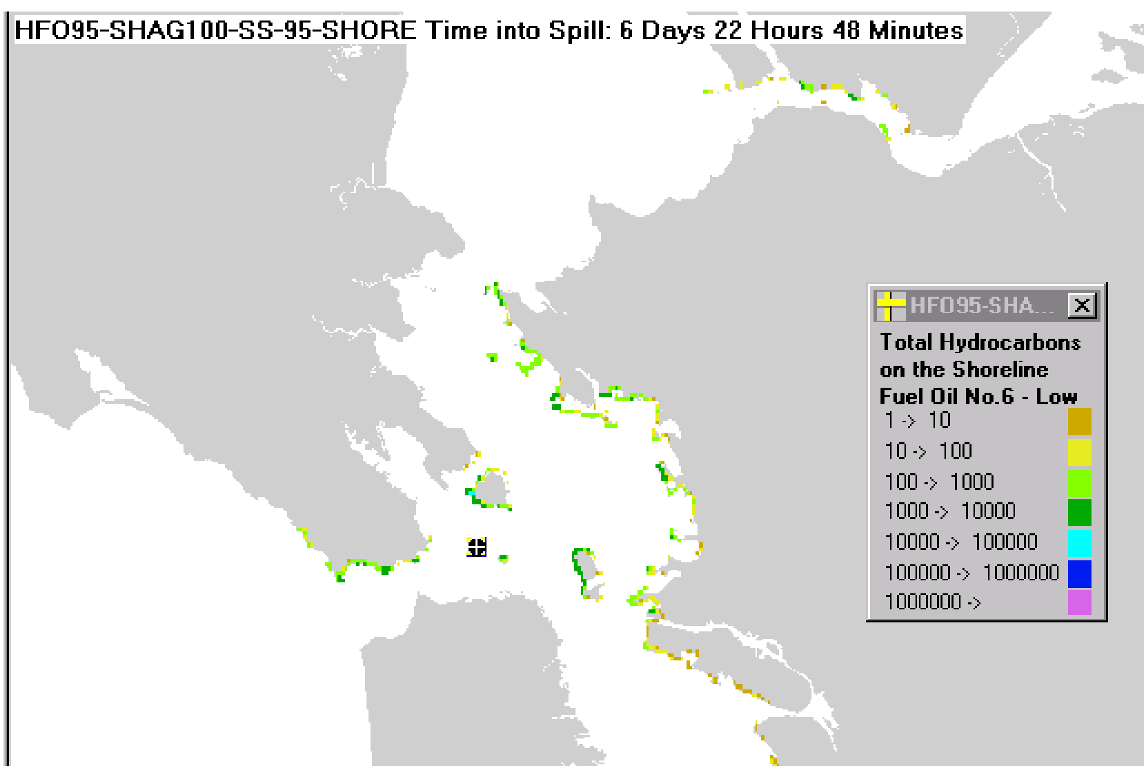
Figures 66 and 67: Shoreline Oiling Degree (g oil/m^2) For HFO 50th Percentile Volumes (Median and Worst Water Column Damage)





Figures 68 and 69: Shoreline Oiling Degree (g oil/m^2) For HFO 95th Percentile Volumes (Median and Worst Water Column Damage)

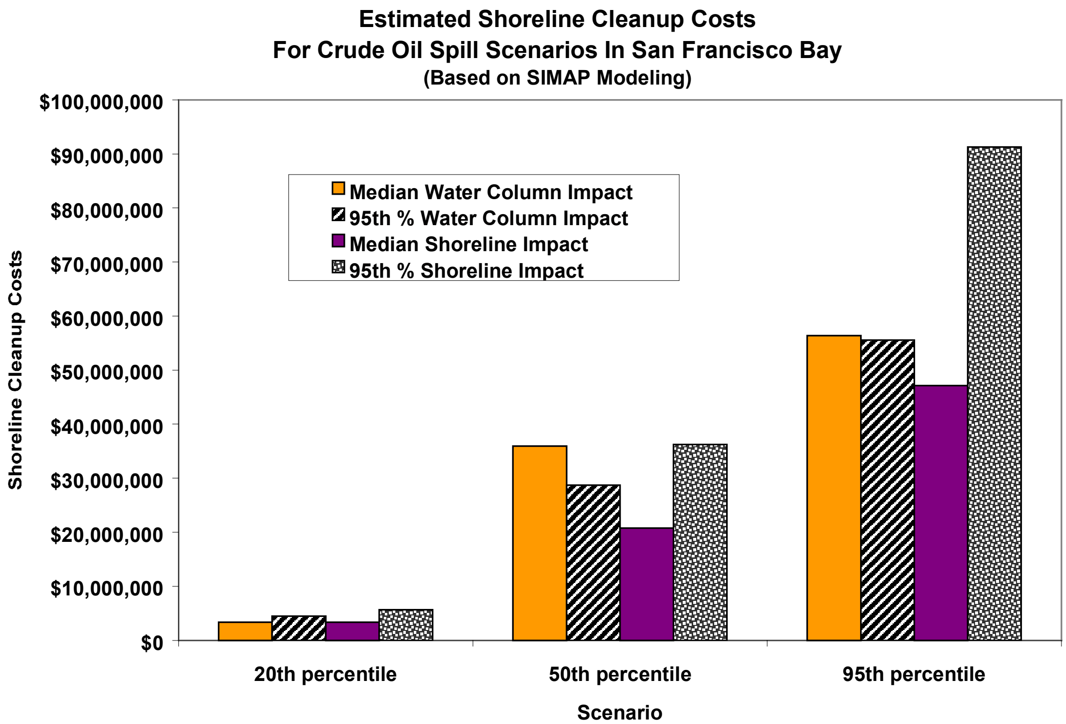




4.5 Shoreline Cleanup For Crude Oil Scenarios

The shoreline cleanup costs for the crude oil spill scenarios based on median and worst (95th percentile) water column and shoreline cost impact are compared in Figure 70.

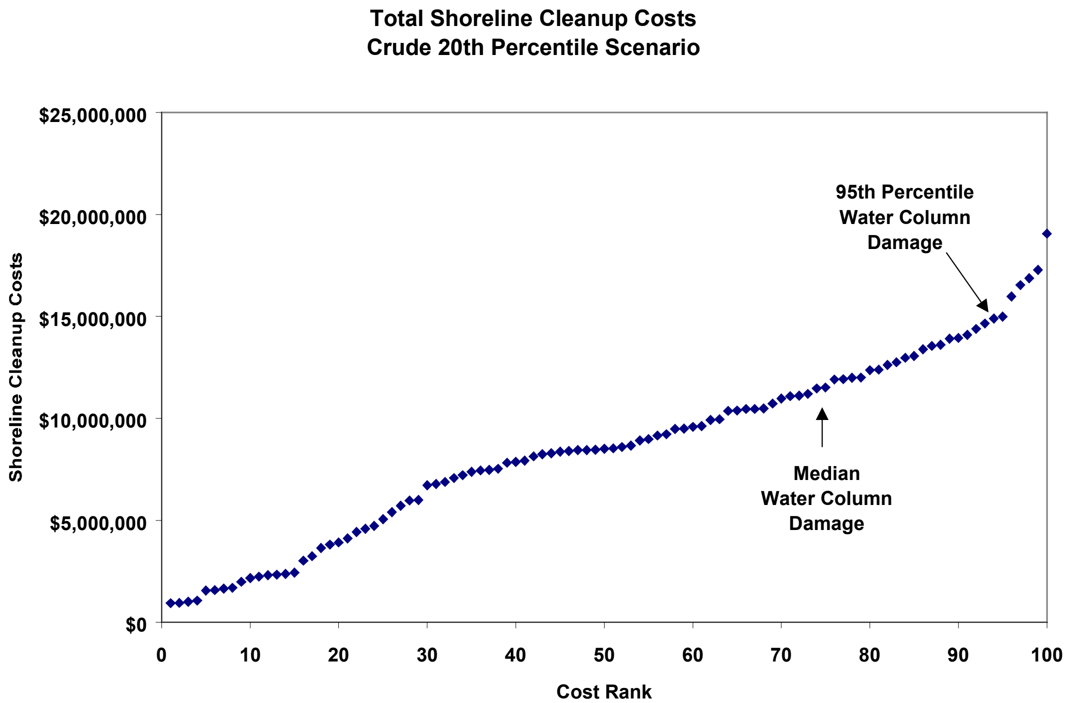
Figure 70

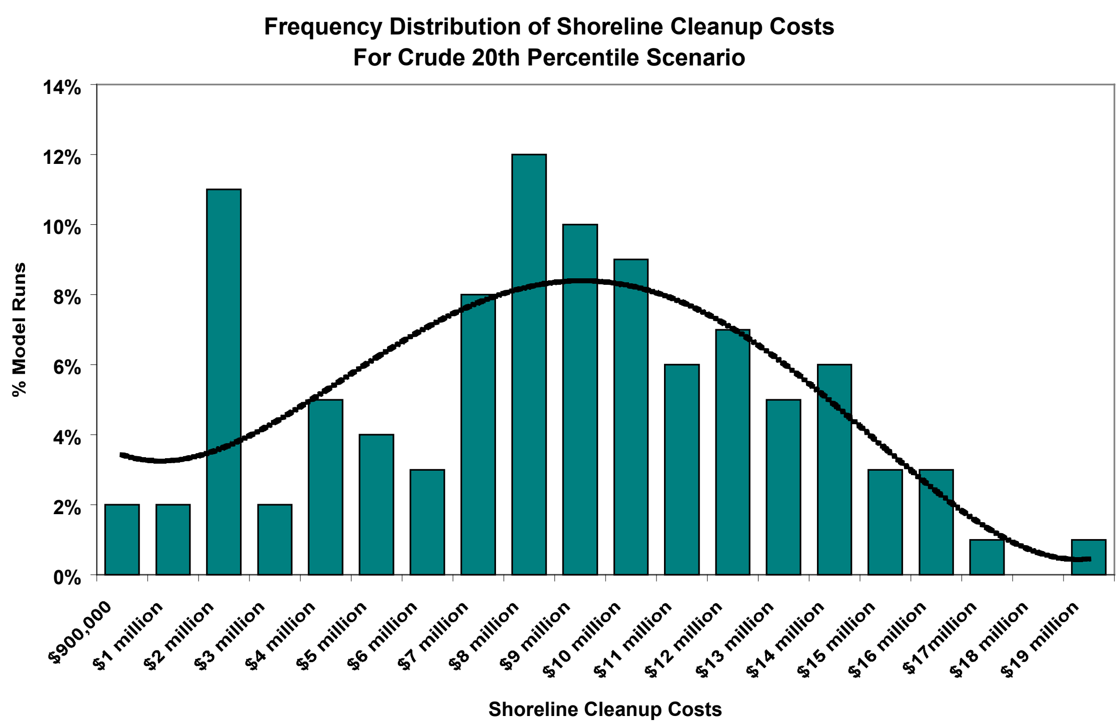


The percentile ranks are based on cost modeling for 100 separate SIMAP spill runs, each of which has a slightly different impact on the shoreline areas of the bay. Figures 71 and 72 show the range of costs for the SIMAP runs for the 20th percentile crude *volume* scenario (100,000 gallons spilled). Figures 73 and 74 show the range of costs for the SIMAP runs for the 50th percentile crude *volume* scenario (600,000 gallons spilled). Figures 75 and 76 show the range of costs for the SIMAP runs for the 95th percentile gasoline *volume* scenario (3,000,000 gallons spilled).

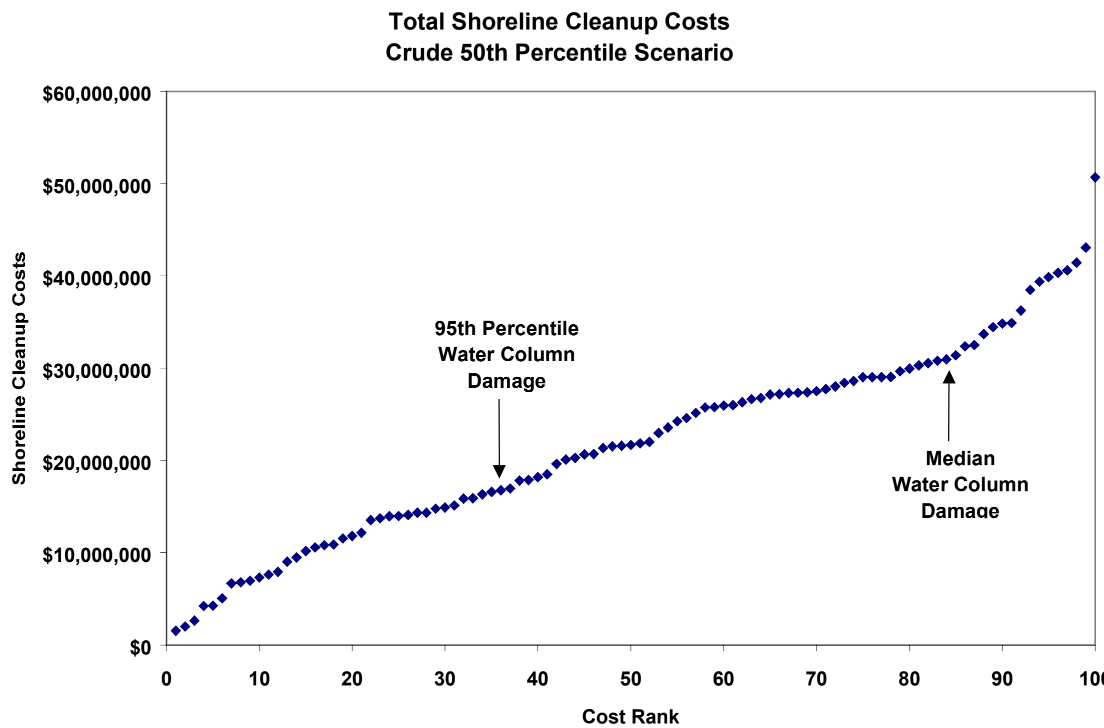
Since the shorelines are weighted differently in terms of the per-square meter cleanup costs, the amount of each type of shoreline impacted is important in determining the costs. The areas of shoreline oiled by crude and the type of shoreline involved are shown in Figures 77-91.

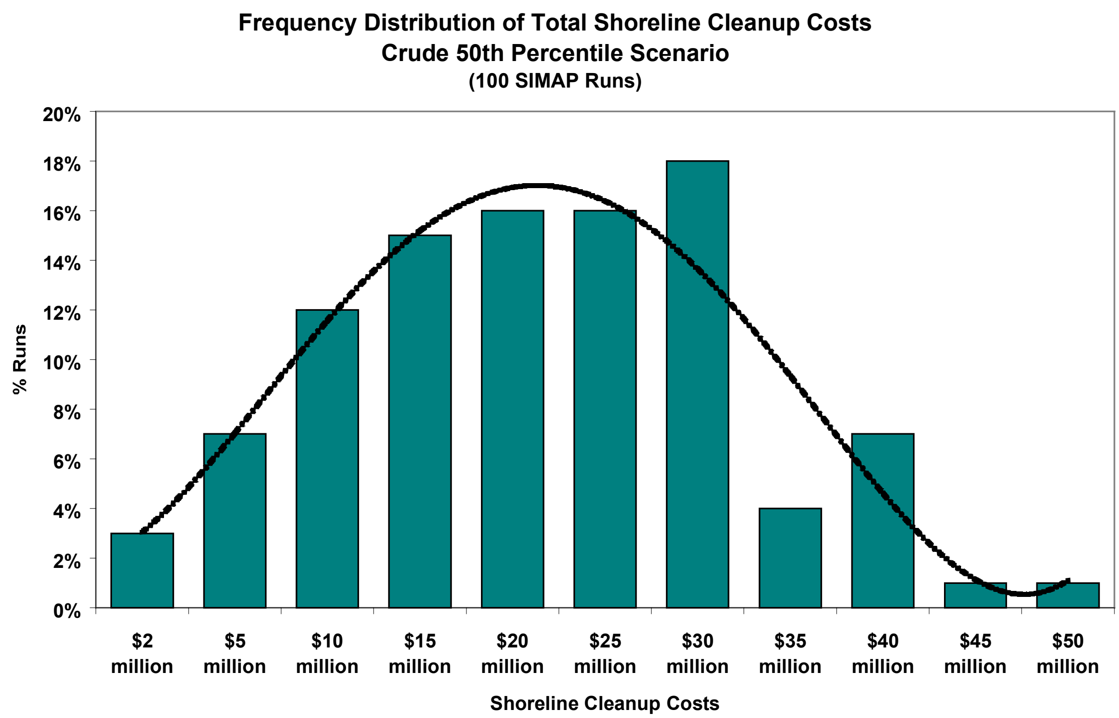
Figures 71 and 72



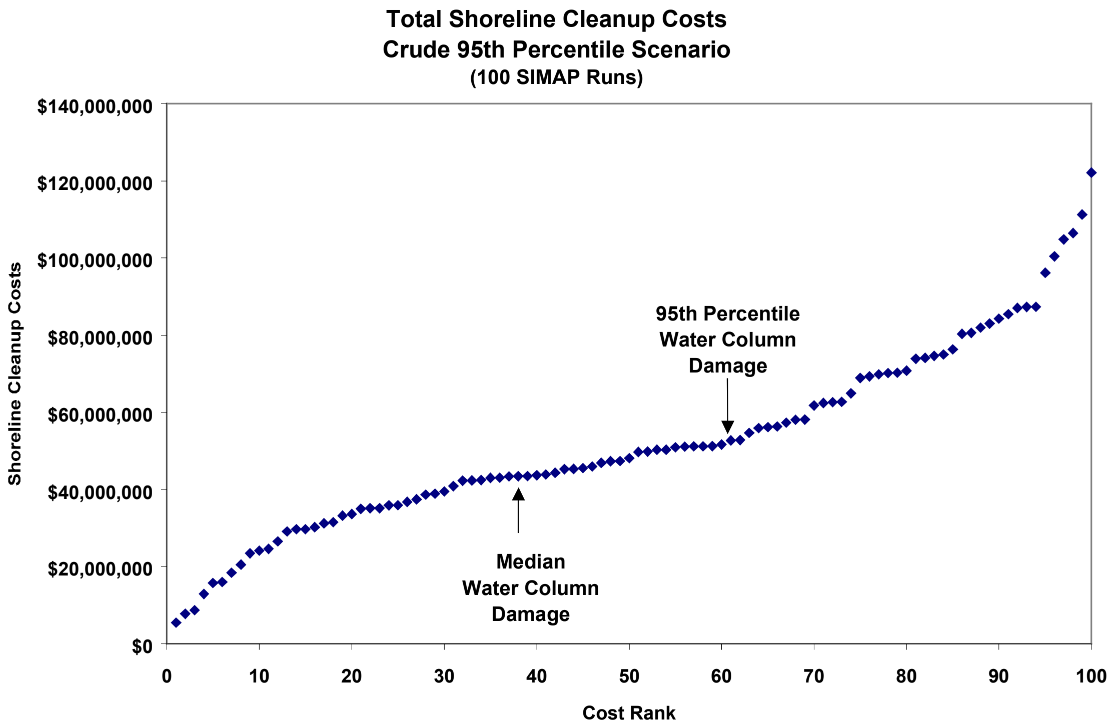


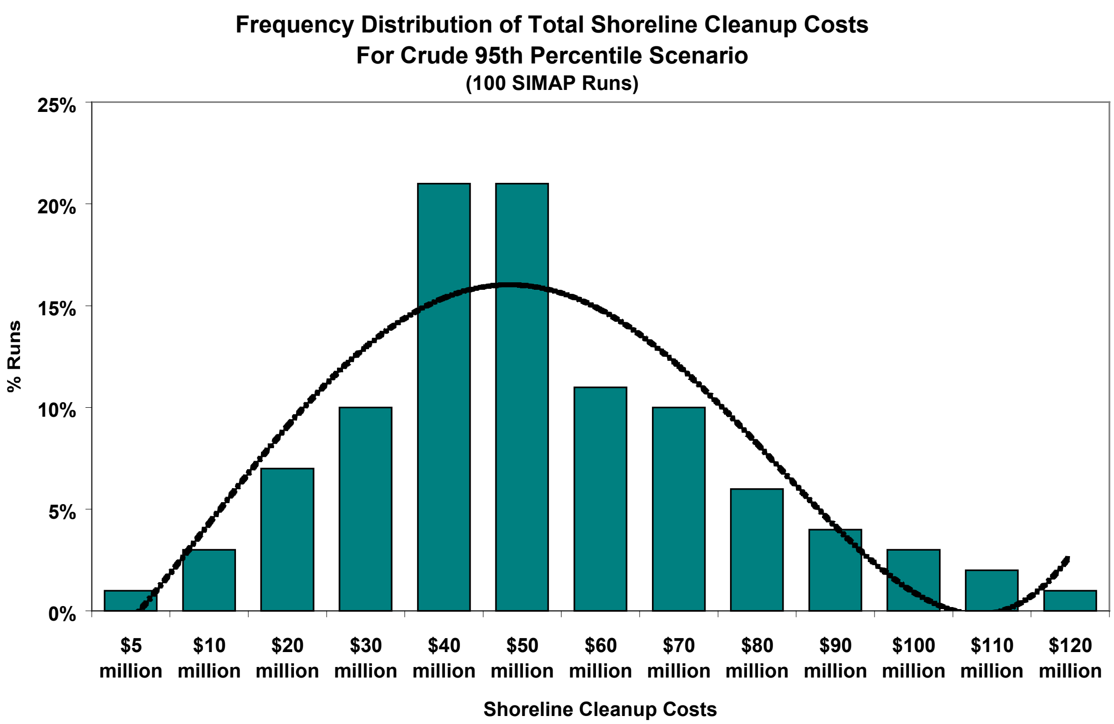
Figures 73 and 74



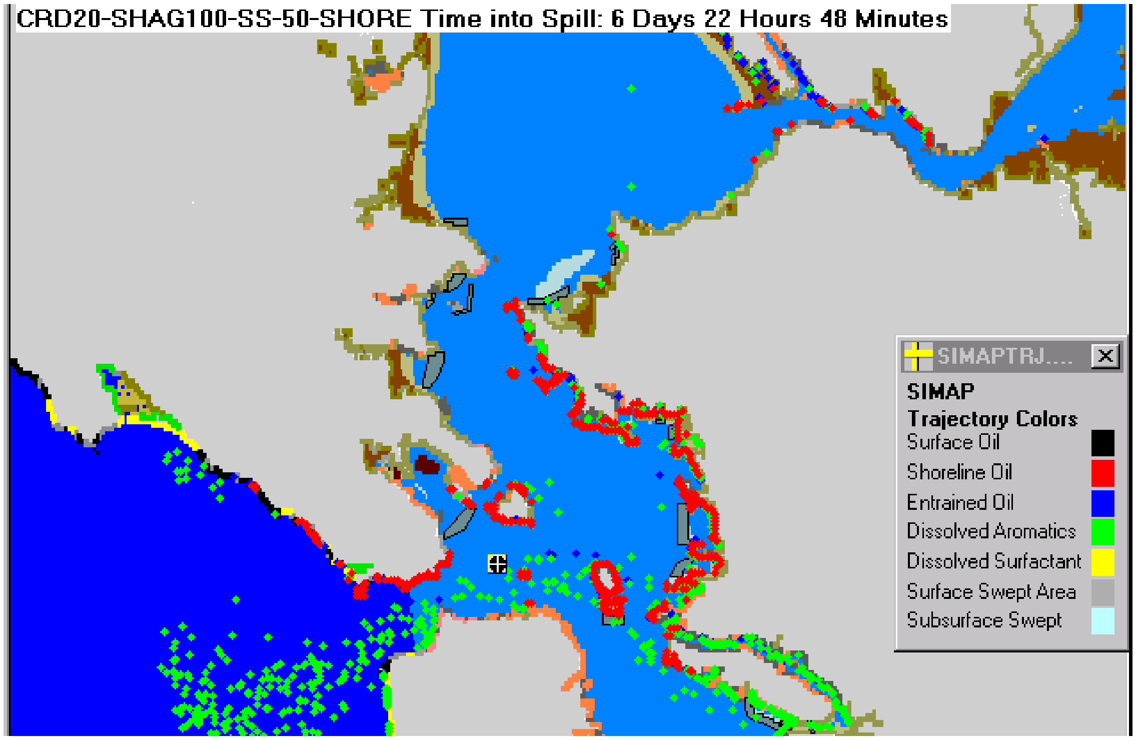


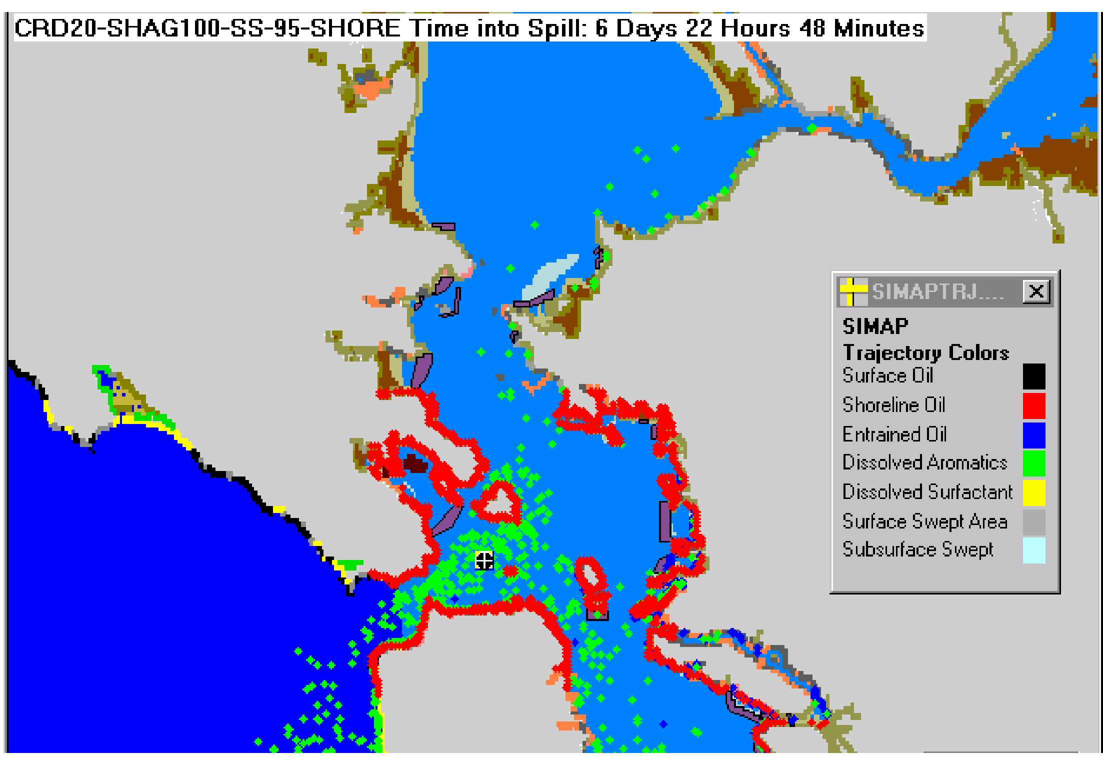
Figures 75 and 76



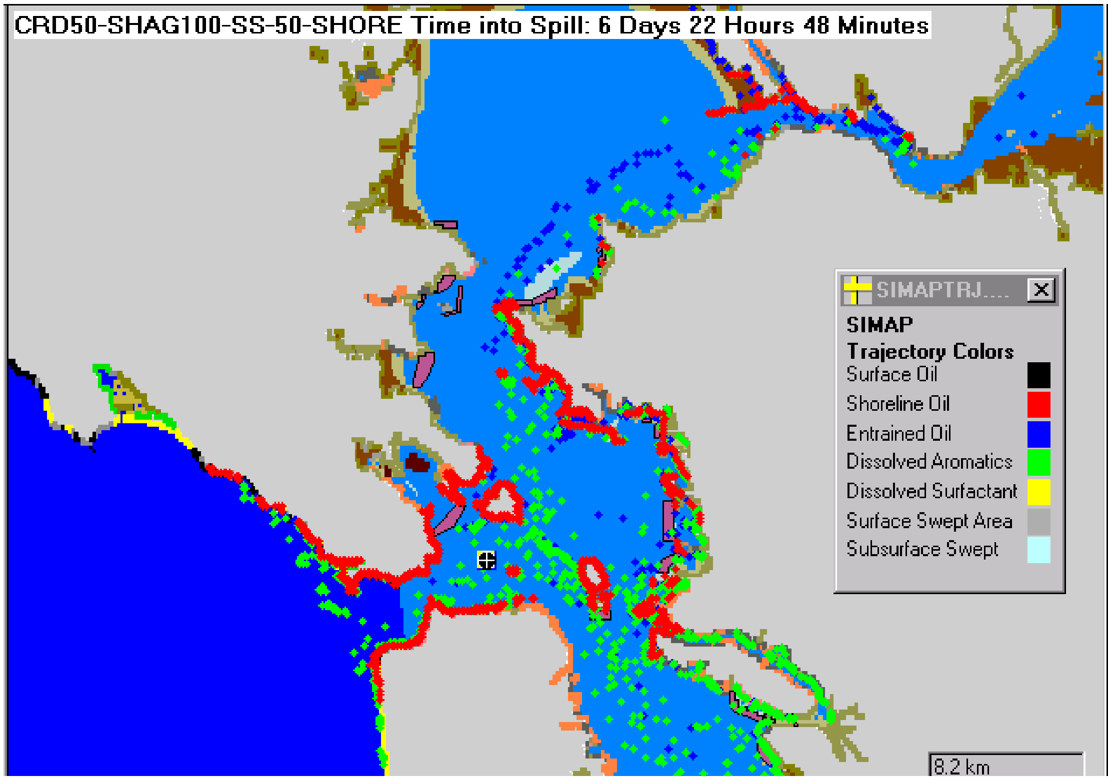


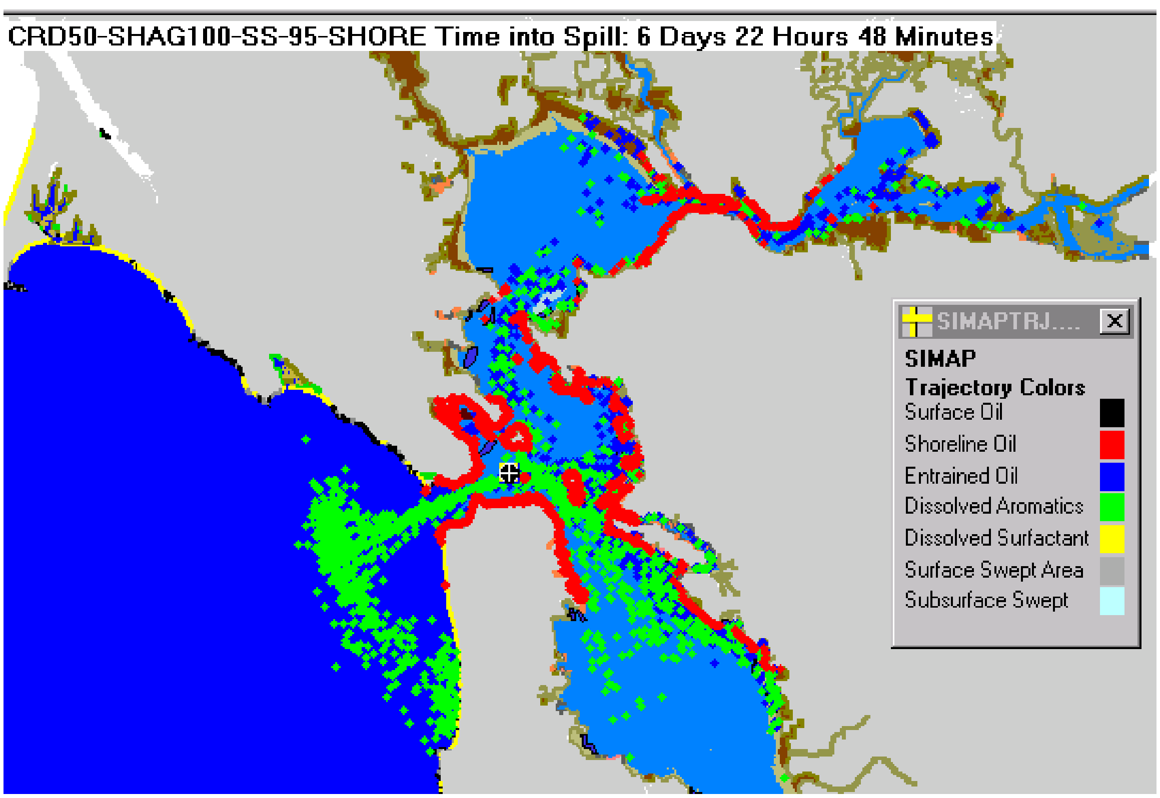
Figures 77 and 78: Oiling for 20th Percentile Volume Crude Scenarios (Median Water Column Damage and Worst Water Column Damage) with shoreline oiling in red



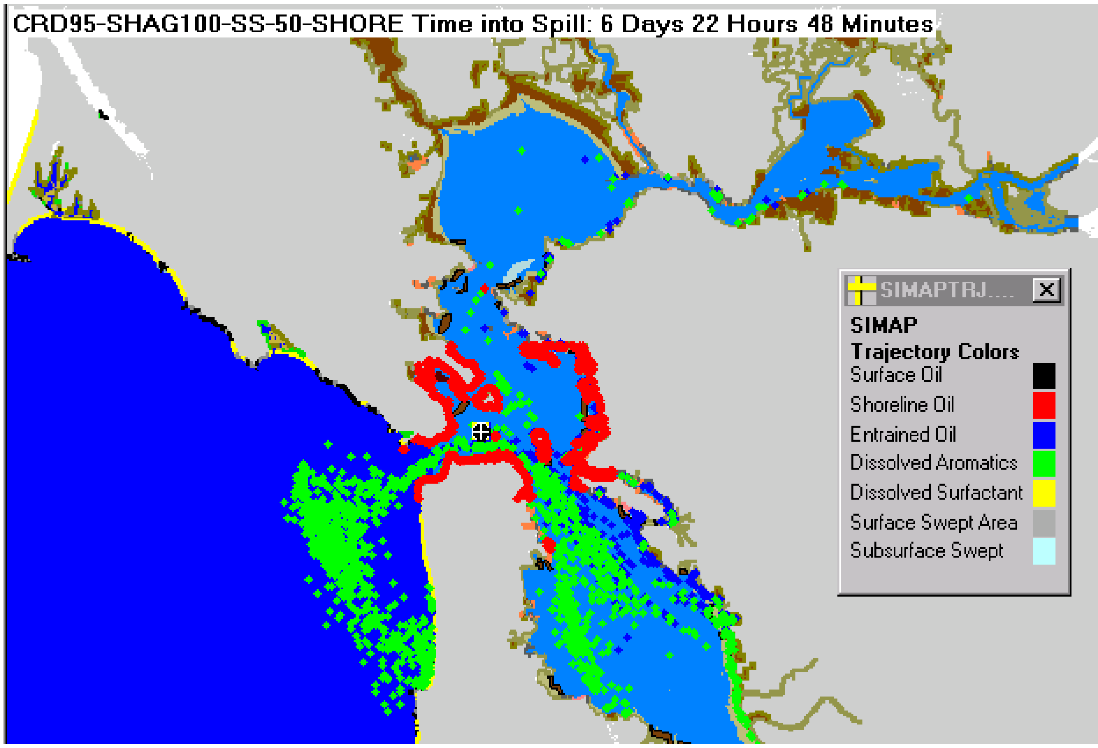


Figures 79 and 80: Oiling for 50th Percentile Volume Crude Scenarios (Median Water Column Damage and Worst Water Column Damage with shoreline oiling





Figures 81 and 82: Oiling for 95th Percentile Volume Crude Scenarios (Median Water Column Damage and Worst Water Column Damage with shoreline oiling in red



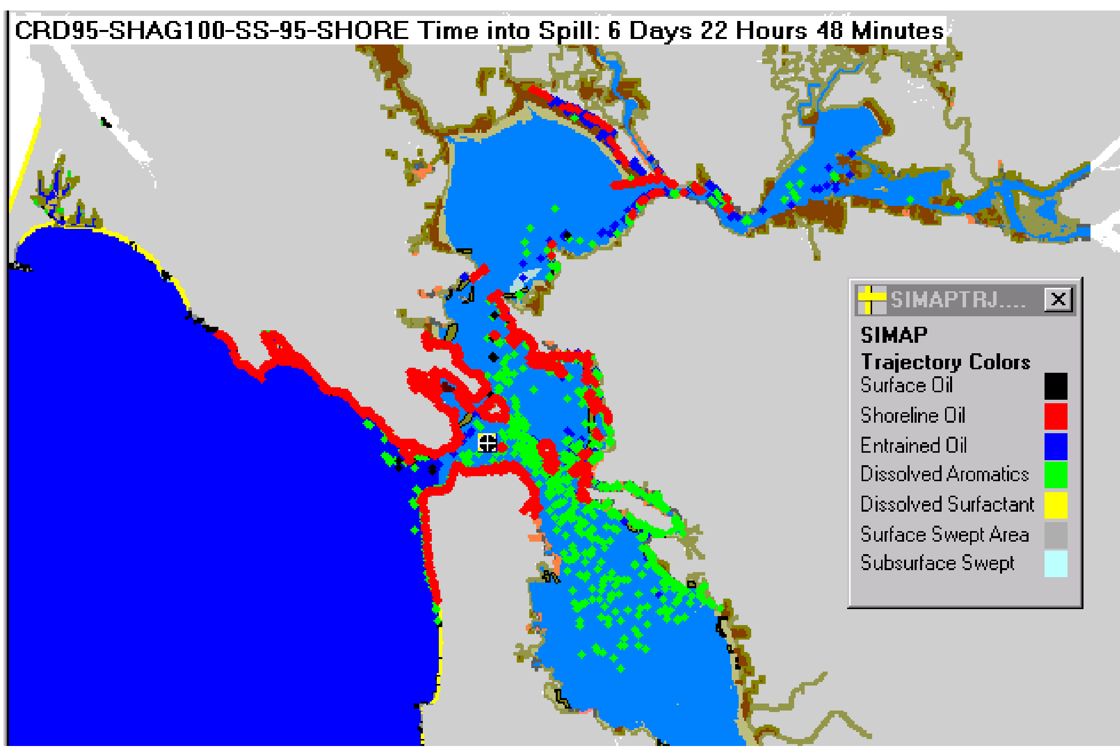


Figure 83: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Crude 20th Percentile Scenario

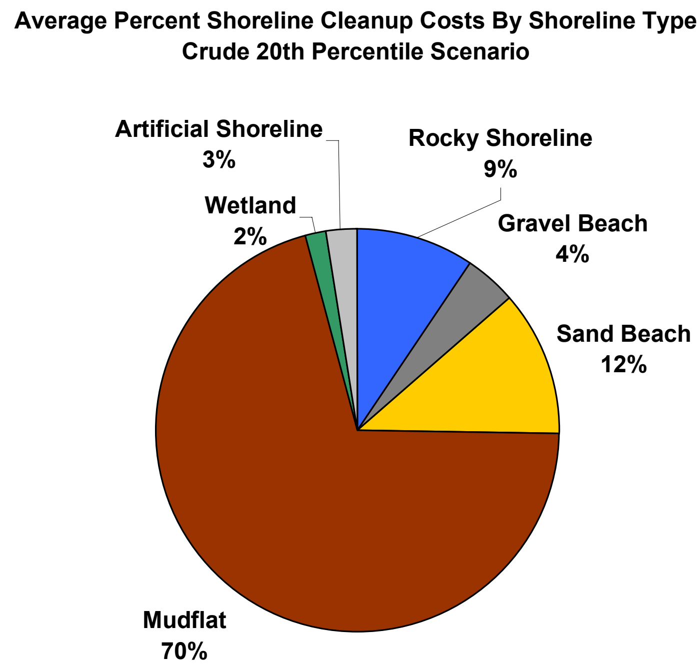


Figure 84: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Crude 50th Percentile Scenario

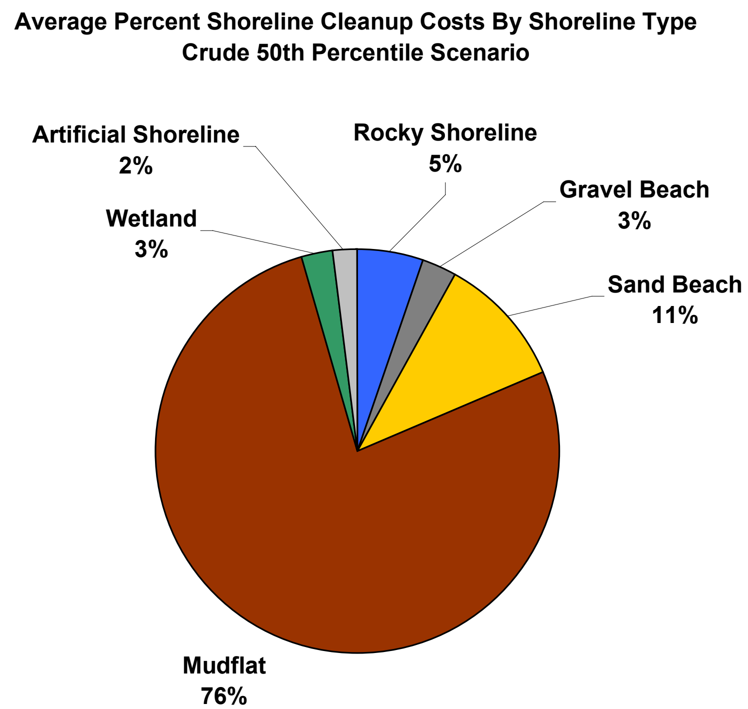
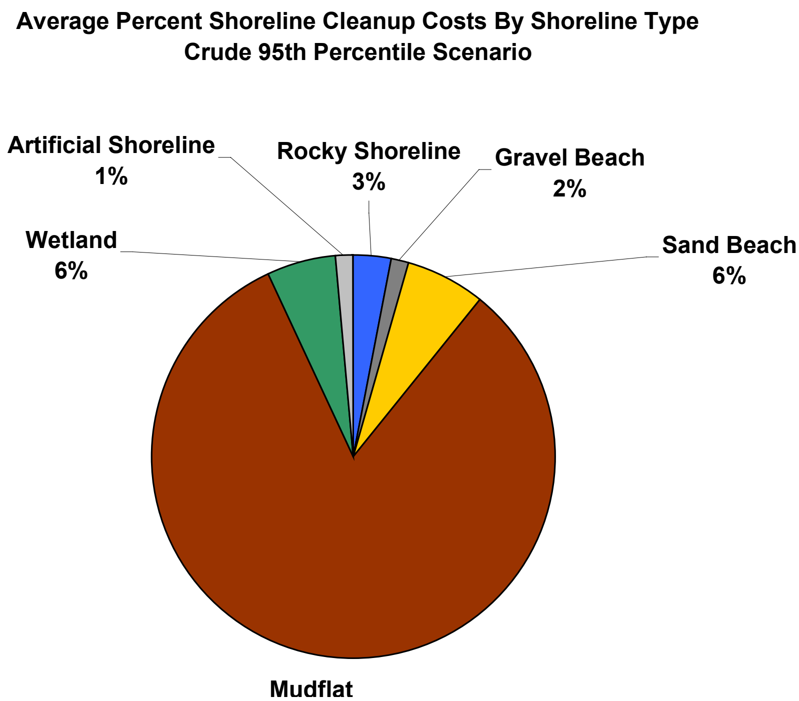
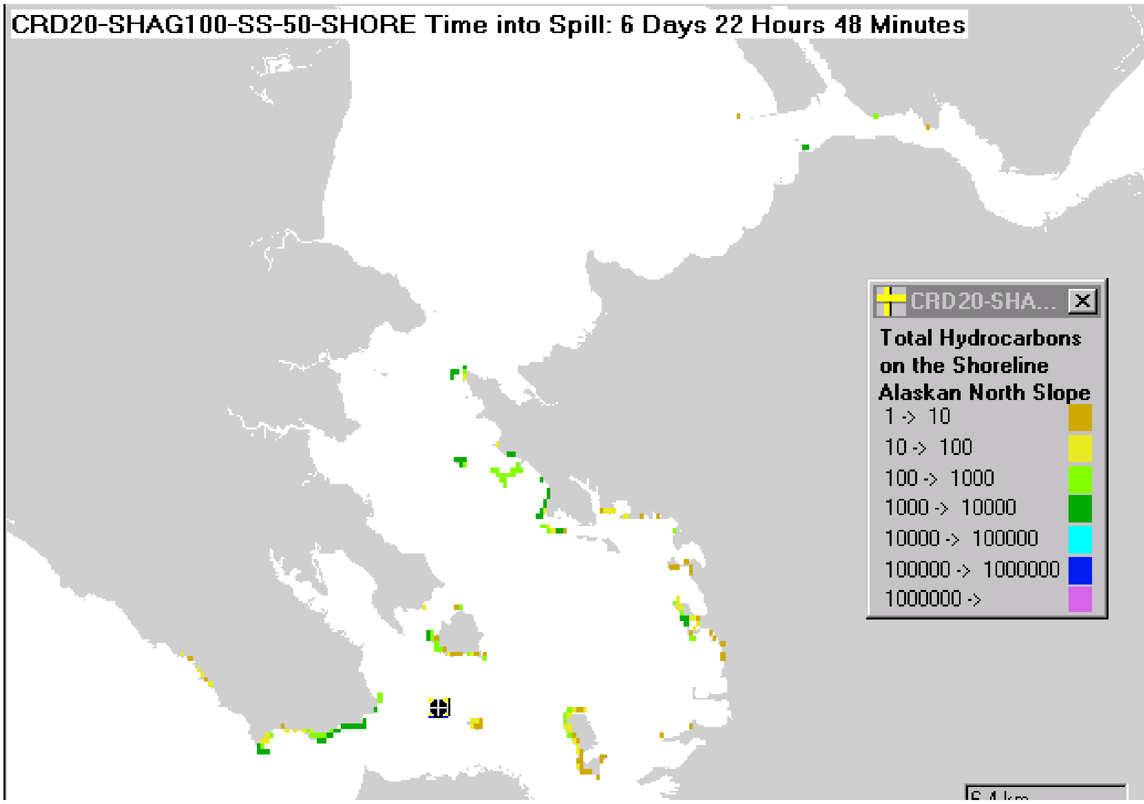
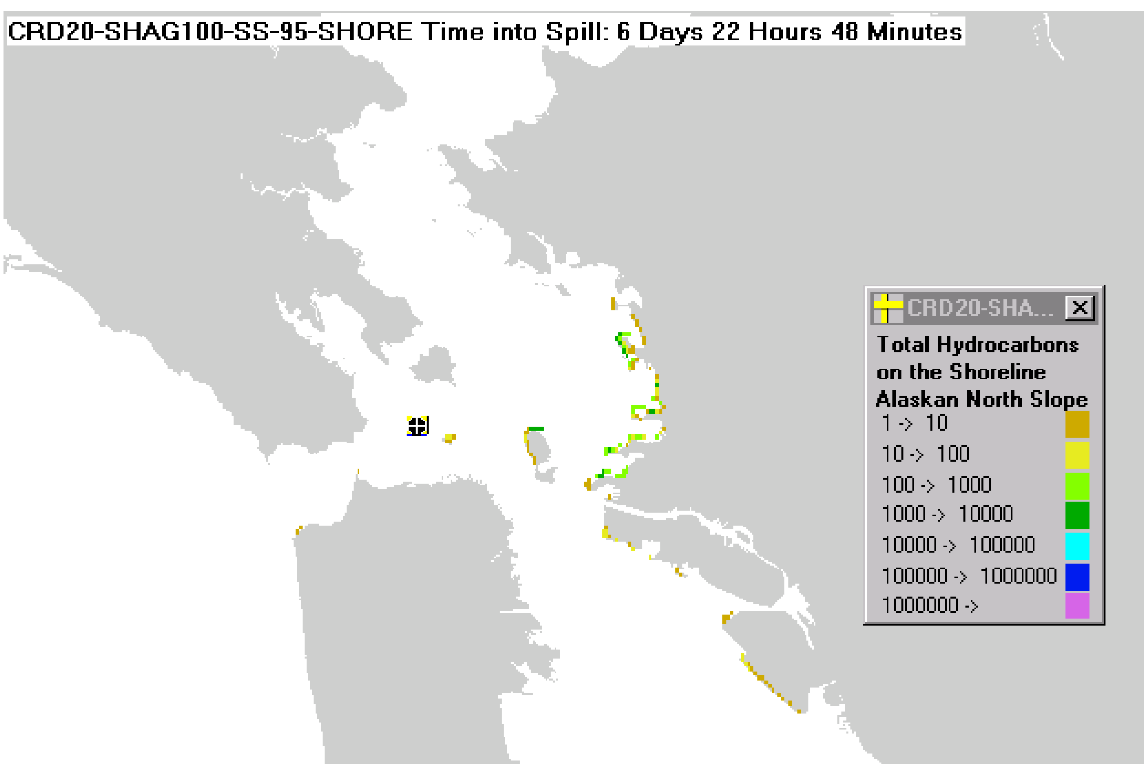


Figure 85: Average Percent Shoreline Cleanup Costs by Shoreline Type (100 runs): Crude 95th Percentile Scenario

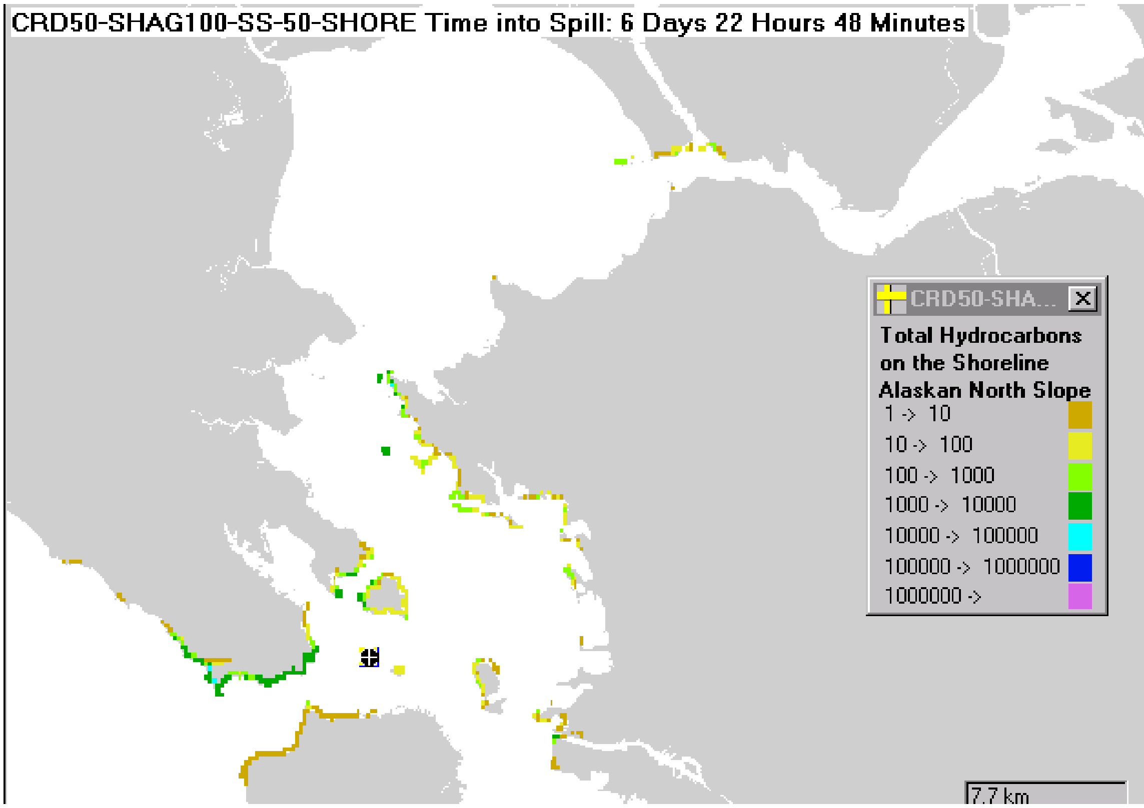


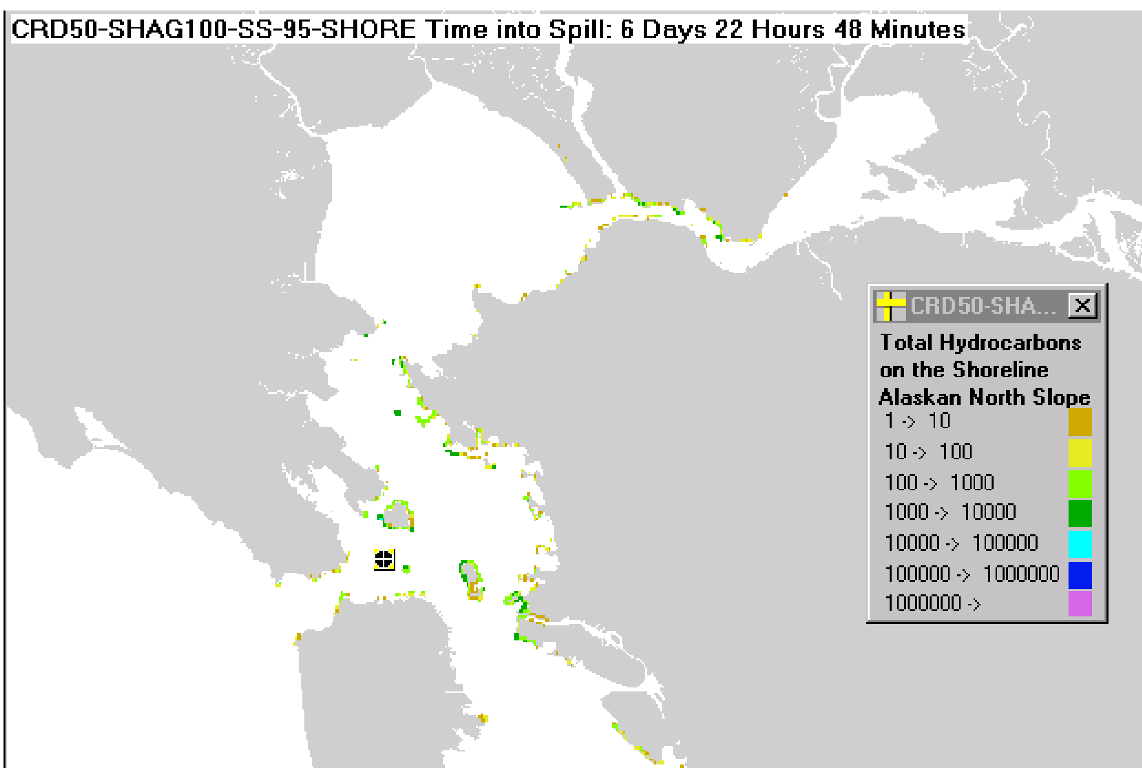
Figures 86 and 87: Shoreline Oiling Degree (g oil/m^2) For Crude 20th Percentile Volumes (Median and Worst Water Column Damage)



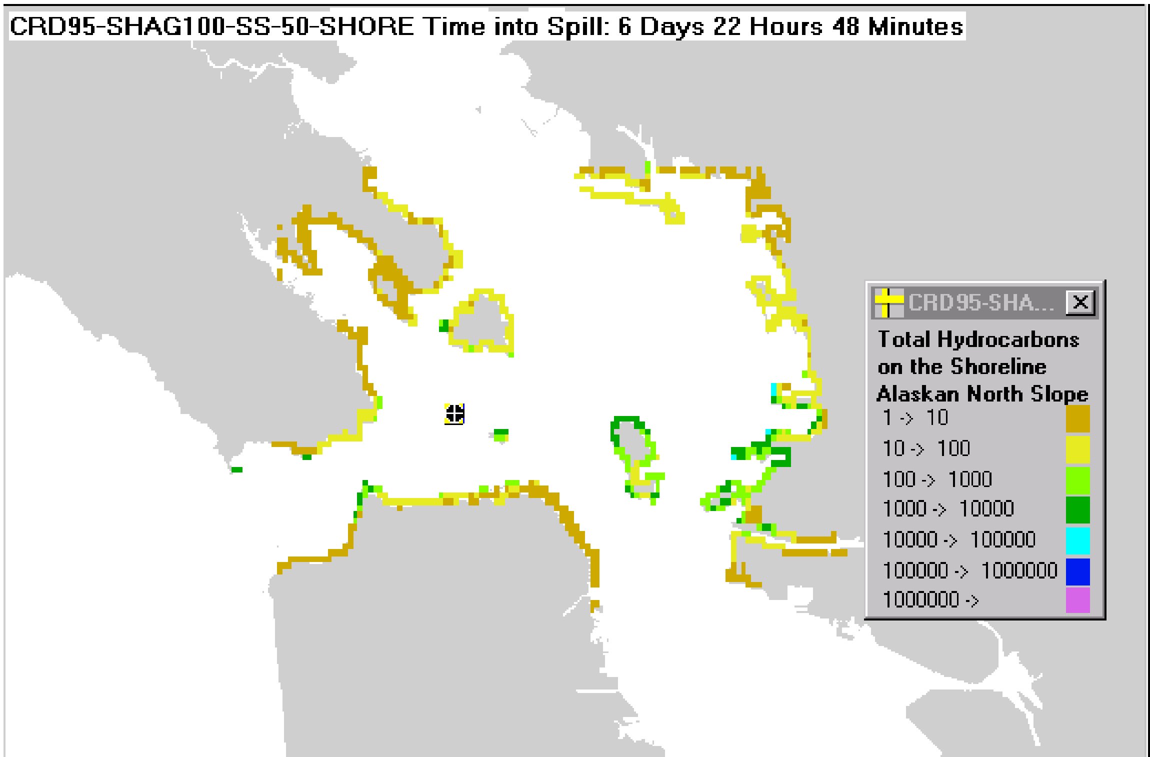


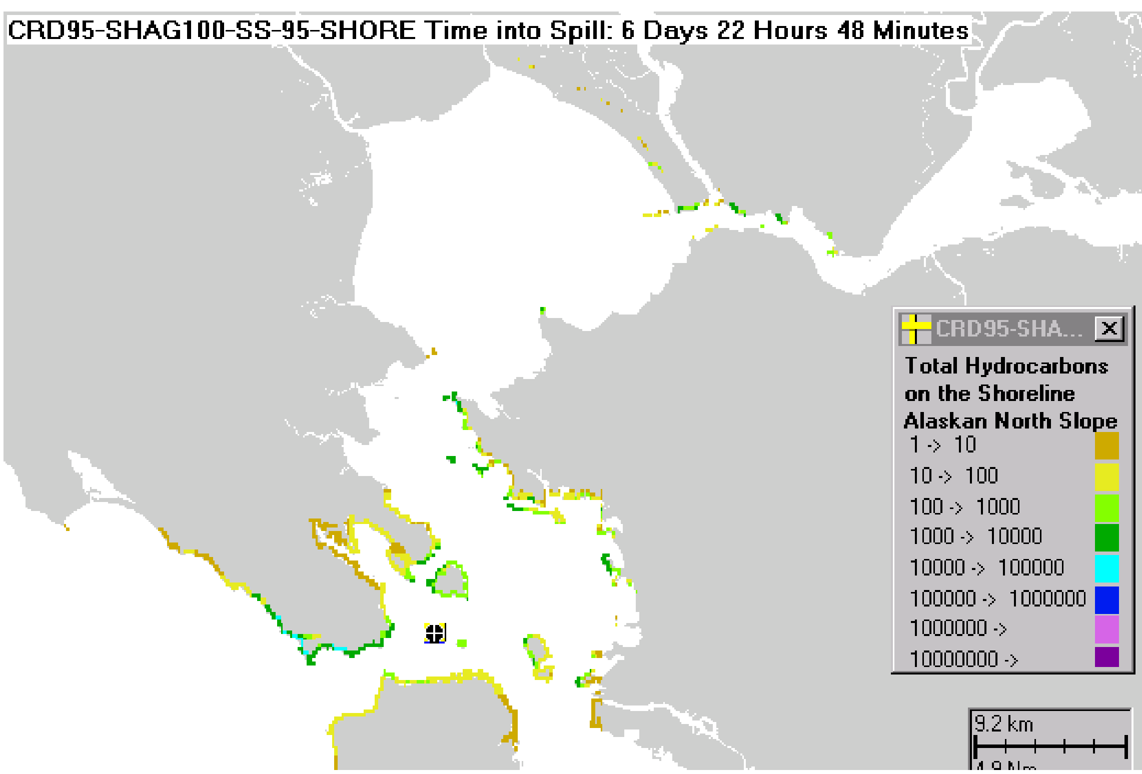
Figures 88 and 89: Shoreline Oiling Degree (g oil/m^2) For Crude 50th Percentile Volumes (Median and Worst Water Column Damage)





Figures 90 and 91: Shoreline Oiling Degree (g oil/m^2) For Crude 95th Percentile Volumes (Median and Worst Water Column Damage)





4.6 Analysis of Variance of Shoreline Cleanup Costs By Shoreline Type

A multiple regression analysis performed on one of the shoreline cleanup cost scenario analyses (HFO 95th percentile volume) shows that 95% of the variation in total cleanup costs is attributable to changes in the mudflat cleanup costs ($F = 1,709$ with 98 df; $p \ll 0.001$), as opposed to 47% for the other shoreline types taken together ($F = 18.5$ with 94 df; $p \ll 0.001$).

For each of the scenarios and for each individual run, the relative percentage of the different shoreline types impacted could significantly impact cleanup costs. The shoreline cleanup costs for each scenario range from lower to higher for each model run depending on the actual shoreline areas for each shoreline type impacted. Thus the total actual shoreline area oiled is not as important as the areas of the most sensitive (and most expensive to clean up) shorelines that are oiled. On average, the greatest costs were associated with mudflat and wetland cleanup because of the higher costs associated with this shoreline type as well as the large percentage of this shoreline impacted by the spills. The range of shoreline cleanup costs, and the average relative percentage of costs (across all 100 runs) by shoreline type, are shown in Figures 92-98.

Figure 92

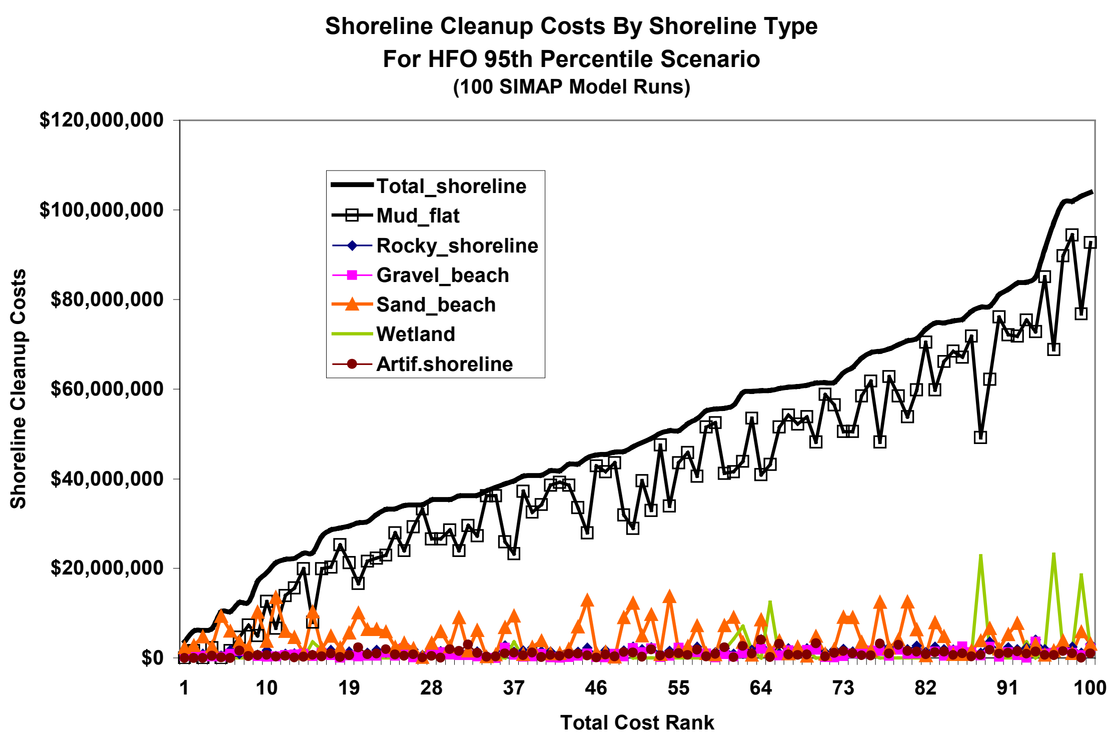


Figure 93

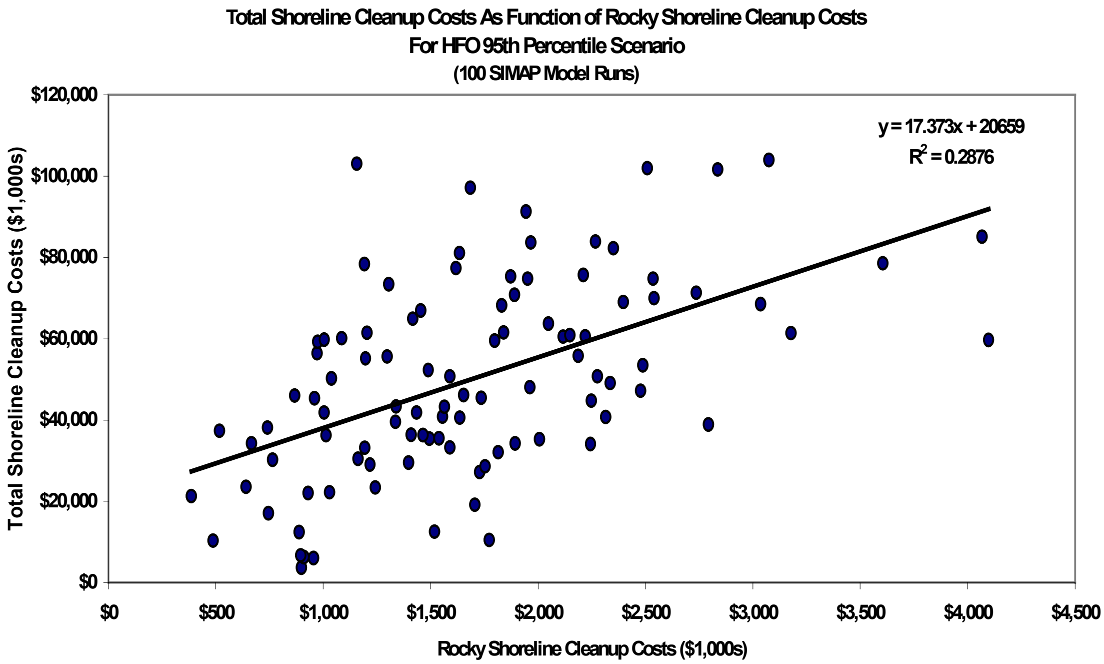


Figure 94

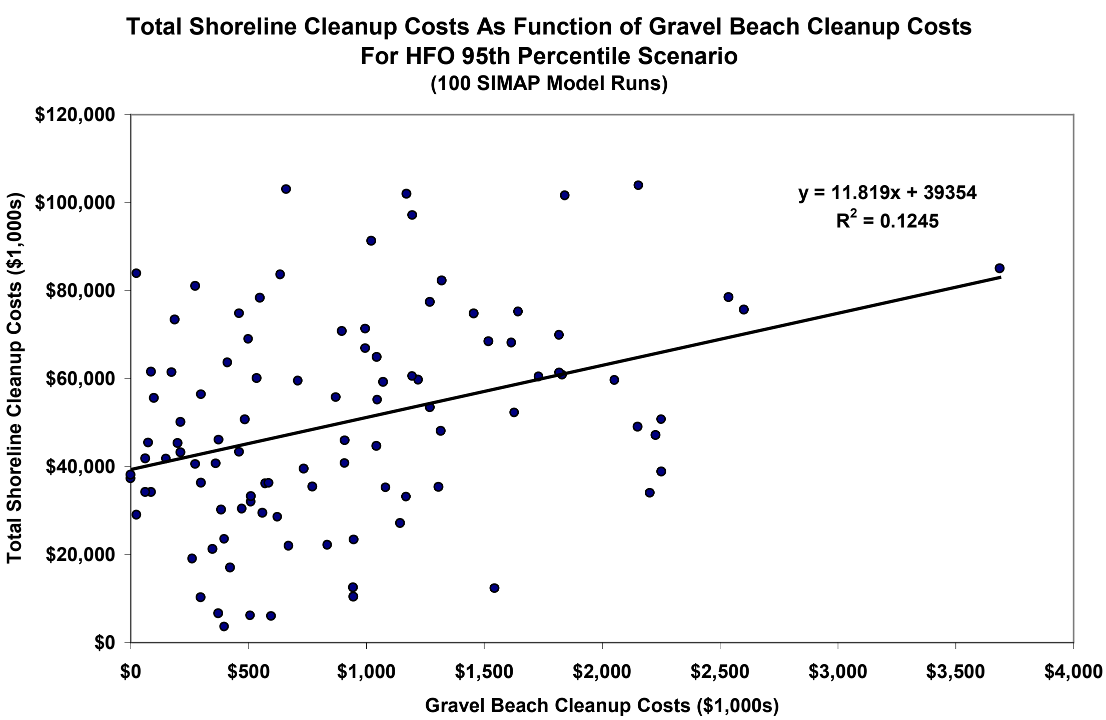


Figure 95

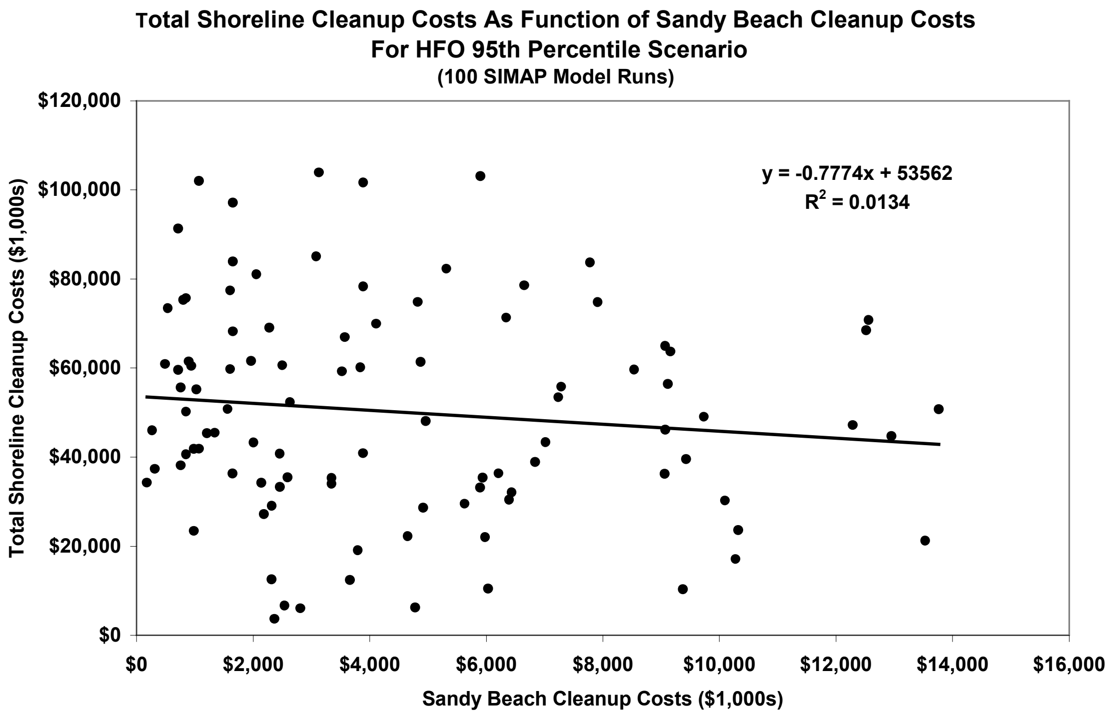


Figure 96

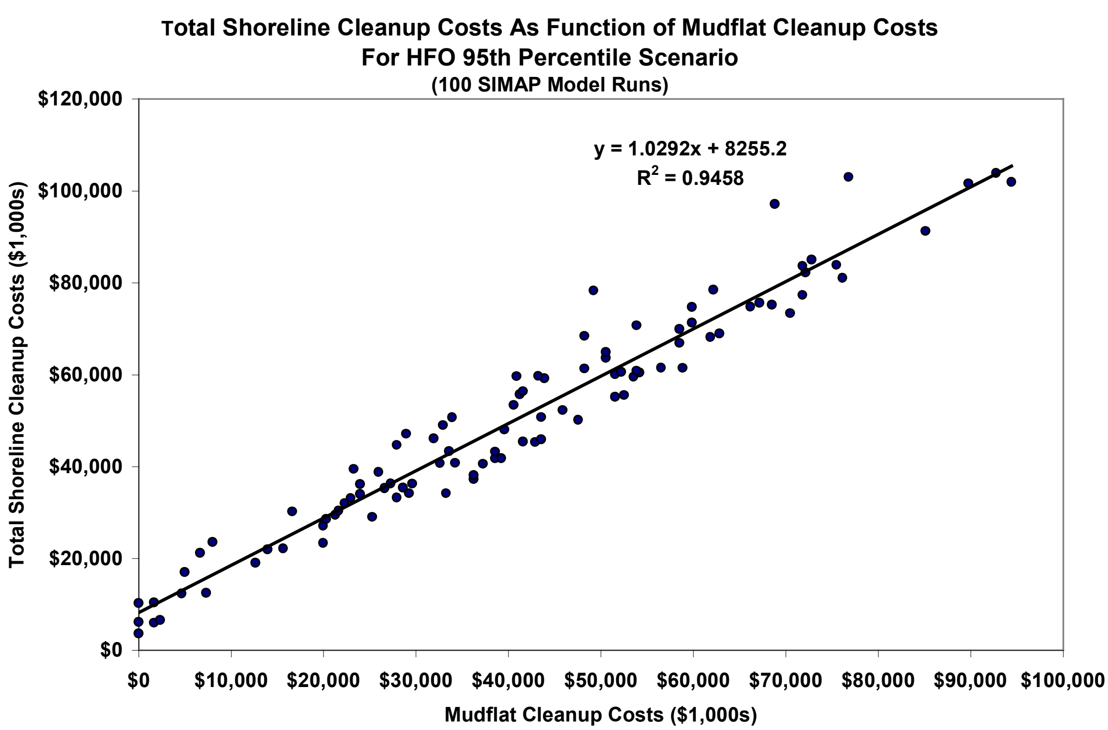


Figure 97

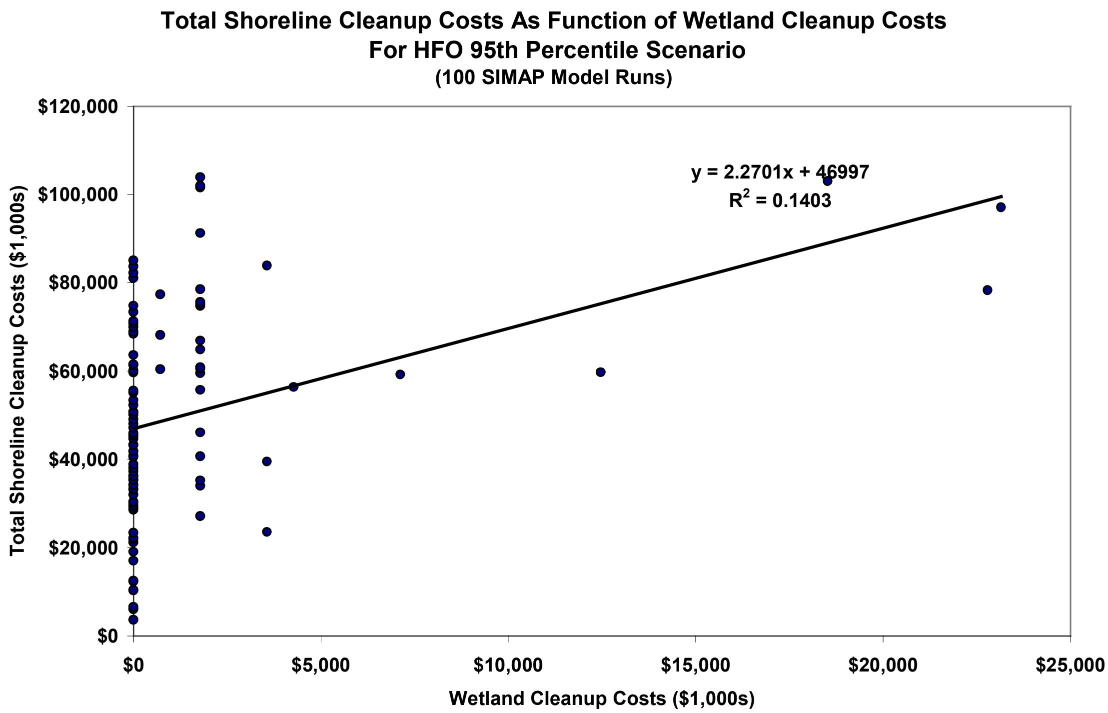
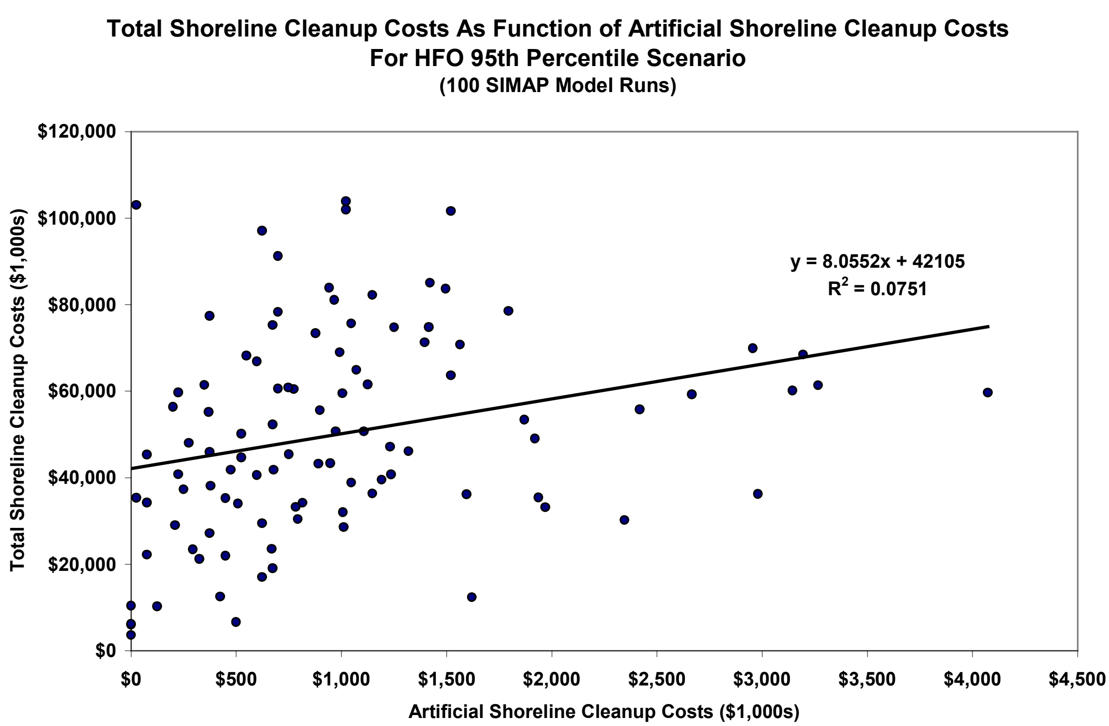


Figure 98



4.7 Shoreline Cleanup Costs With Disposal Costs

Shoreline cleanup costs that *include* disposal costs are shown in Table 10. These costs can be formidable since they can involve the removal and transport of a large volume of oily debris, especially from sandy beaches, mudflat, and wetland areas.

Table 10

Estimated Total Shoreline Cleanup Costs For San Francisco Bay Spill Scenarios Based on SIMAP Modeling and ERC Cost Analysis						
Scenario		**Estimated Shoreline Cleanup Costs**				
Fuel	**Spill Size (gallons)**	**Shoreline Costs Median Impact[1]**	**Shoreline Costs Worst Impact[2]**	**Disposal Costs**	**Median Impact[1] Shoreline + Disposal Costs**	**Worst Impact[2] Shoreline + Disposal Costs**
Diesel	50,000	$2,080,000	$4,260,000	$32,500	$2,112,500	$4,292,500
	270,000	$7,303,000	$1,593,000	$175,500	$7,478,500	$1,768,500
	1,250,000	$11,570,000	$16,340,000	$812,500	$12,382,500	$17,152,500
Gasoline	50,000	$16,000	$2,000	$10,000	$26,000	$12,000
	270,000	$150,000	$116,000	$54,000	$204,000	$170,000
	1,250,000	$295,000	$1,918,000	$250,000	$545,000	$2,168,000
Heavy fuel oil	25,000	$3,370,000	$5,670,000	$380,000	$3,750,000	$6,050,000
	100,000	$20,770,000	$36,200,000	$1,520,000	$22,290,000	$37,720,000
	410,000	$47,140,000	$91,260,000	$6,232,000	$53,372,000	$97,492,000
Crude	100,000	$8,510,000	$14,990,000	$1,200,000	$9,710,000	$16,190,000
	600,000	$21,670,000	$39,870,000	$7,200,000	$28,870,000	$47,070,000
	3,000,000	$48,120,000	$96,160,000	$36,000,000	$84,120,000	$132,160,000

[1]50th percentile *water column* impact run for diesel and gasoline scenarios; 50th percentile *shoreline cost* impact for heavy fuel oil and crude scenarios.
[2]95th percentile *water column* impact run for diesel and gasoline scenarios; 95th percentile *shoreline cost* impact for heavy fuel oil and crude scenarios.

5.0 Total Mechanical Recovery Costs Including Shoreline Cleanup Costs

Total response operations costs for on-water mechanical containment and recovery *plus* shoreline cleanup are shown in Figure 99 and Table 11. These include costs for salvage and lightering operations necessary for source control and vessel stabilization as well as costs associated with spill management.

Figure 99

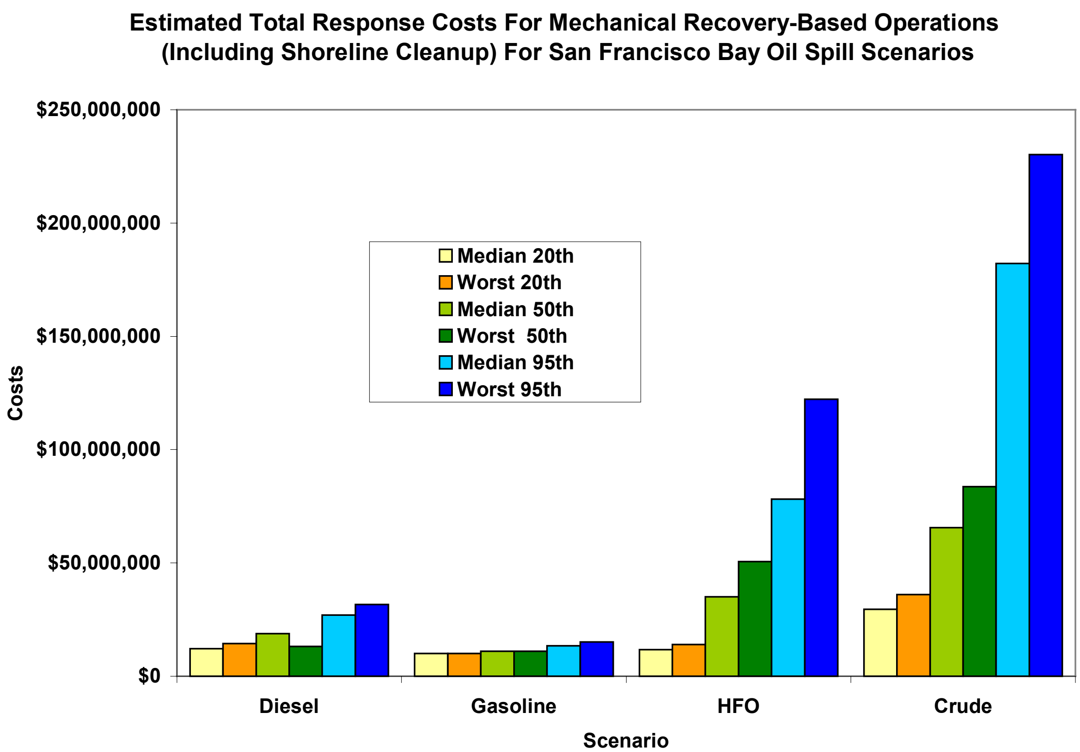


Table 11

Estimated Total Response Costs (With Mechanical Recovery)						
Spill Scenario		Estimated Costs				
Oil Type	Scenario Percentile	On-Water Mechanical Recovery[1]	Shoreline Cleanup[1,2] median/worst	Salvage/ Source Control	Spill Mgt	Total Cost[2] median worst
Diesel	20th	$893,000	$2,113,000	$9,000,000	$200,000	$12,205,500
			$4,293,000			$14,385,500
	50th	$2,010,000	$7,479,000	$9,000,000	$300,000	$18,788,500
			$1,769,000			$13,078,500
	95th	$4,512,000	$12,383,000	$9,000,000	$1,000,000	$26,894,500
			$17,153,000			$31,664,500
Gasoline	20th	$825,000	$26,000	$9,000,000	$170,000	$10,021,000
			$12,000			$10,007,000
	50th	$1,620,000	$204,000	$9,000,000	$220,000	$11,044,000
			$170,000			$11,010,000
	95th	$3,207,000	$545,000	$9,000,000	$650,000	$13,402,000
			$2,168,000			$15,025,000
Heavy Fuel Oil	20th	$2,470,000	$3,750,000	$5,000,000	$400,000	$11,619,000
			$6,050,000			$13,919,000
	50th	$6,817,000	$22,290,000	$5,000,000	$1,000,000	$35,107,000
			$37,720,000			$50,537,000
	95th	$17,915,000	$53,372,000	$5,000,000	$1,800,000	$78,087,000
			$97,492,000			$122,207,000
Crude	20th	$6,839,000	$9,710,000	$12,000,000	$1,000,000	$29,549,000
			$16,190,000			$36,029,000
	50th	$22,628,000	$28,870,000	$12,000,000	$2,000,000	$65,498,000
			$47,070,000			$83,698,000
	95th	$78,024,000	$84,120,000	$12,000,000	$8,000,000	$182,144,000
			$132,160,000			$230,184,000

[1]Includes disposal costs and decontamination costs as appropriate.
[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

6.0 Costs For Chemical Dispersant Operations

Costs for a response in which chemical dispersants are used as a first-order response tool *instead of* on-water mechanical containment and recovery were calculated for the San Francisco Bay spill scenarios as it is likely that chemical dispersion will become a viable response option in the San Francisco Bay area during the coming decade, according to a report from the California Office of Spill Prevention and Response, US Coast Guard, and American Petroleum Institute (Pond *et al*. 2000).

The use of dispersants requires approval by state and federal authorities, usually in the form of a pre-authorization agreement. Preauthorization or pre-approval agreements are based on an environmental benefit analysis of the specific location(s) involved in a spill scenario. The cost calculations made here assume that all proper and necessary authorization and approval has taken place in advance or within a reasonable time frame to allow for effective use of chemical dispersion agents.

The following assumptions are made in developing the cost model (based on Pond *et al*. 2000; Etkin 1999*b;* Moller *et al*. 1987; Allen and Ferek 1993):

1. All necessary dispersant approvals and/or authorizations are in place.
2. All vessels and airplanes equipped with fire monitors are available for deployment.
3. Weather conditions are suitable for flying airplanes and conducting all other aspects of dispersant application can be conducted safely.
4. The dispersant-to-oil ratio used in all operations is 1:20 (5 gallons/acre).
5. Corexit 9500 is applied to HFO and Corexit 9527 is applied to other oil types.
6. Both Corexit 9500 and Corexit 9527 are available in the San Francisco Bay area. [In 2002, only Corexit 9527 is being stockpiled. The results of the California Office of Spill Prevention and Response study (Pond *et al*. 2000) are being evaluated to determine whether it may be advisable to additionally stockpile Corexit 9500 in the near future.]
7. The number of C-130 aircraft sorties required is determined by Figure 100 and Tables 12 and 13.
8. Hourly charges for the C-130 aircraft (including field operational support, administrative support, and depreciation) would follow US Coast Guard standard rates for non-government operations ($5,445/hour in 2001 $). All fractional hour usage is billed to next highest hour charge as per US Coast Guard policy.
9. Two additional hours of C-130 aircraft usage costs are factored in to allow for transit to and from spill site.
10. The “lower” dispersant efficiency is 35% for HFO and 40% for the other oil types; the “higher” dispersant efficiency is 70% for HFO and 80% for the other oil types. HFO is generally less dispersible due to its higher viscosity. These values were used to reduce shoreline oiling and resultant shoreline cleanup costs proportionately.
11. Dispersant is applied to the oil that still remains on the surface 12 hours after the spill occurs.
12. Dispersant chemicals cost $41/gallon.

Figure 100

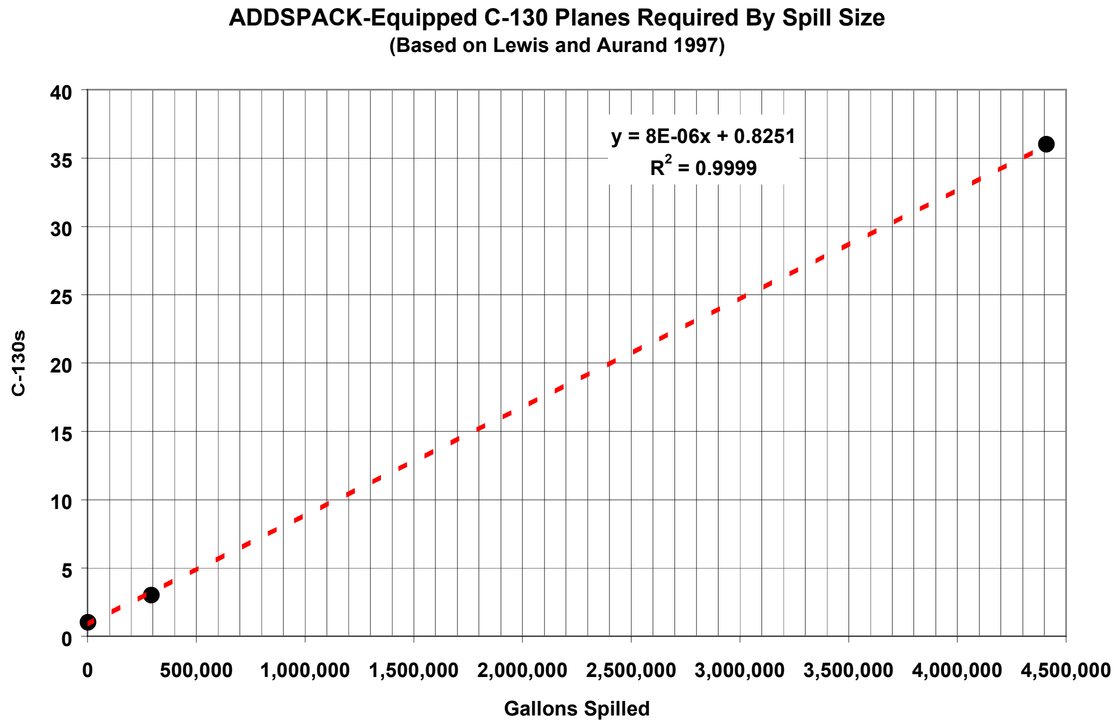


Table 12

Dispersant Platform Sortie Requirements By Spill Size				
Spill Size	**Amount Dispersant Needed To Treat Entire Spill**	**Sorties Small Helo**	**Sorties Large Helo**	**Sorties ADDSPACK-equipped C-130 Aircraft**
2,100 gallons	105 gallons	1	1	1
294,000 gallons	12,810 gallons	50	17	3
4,410,000 gallons	192,510 gallons	750	250	36
Source: Lewis and Aurand 1997				

Table 13

Dispersant Application Platform Parameters						
Specifications	**Application Platform Type**					
	Bell 212 Suspended Bucket	**C130 with ADDSPACK**	**DC-4**	**Air Tractor**	**Large Vessel (100 ft.)**	**Small Vessel (20-40 ft.)**
Swath Width	55 ft	150 ft	120 ft	85 ft	80 ft	95 ft
Application Speed	60 knots	145 knots	156 knots	150 knots	7 knots	14 knots
Pump Rate	52 gal/min	106 gal/min	340 gal/min	382 gal/min	142 gal/min	585 gal/min
Reposition Speed	80 knots	140 knots	165 knots	150 knots	continuous spray	--
Transit Speed	80 knots	260 knots	174 knots	200 knots	15 knots	25 knots
Dispersant Load Time	2 min	20 min	20 min	10 min	60 min	10 min
Fuel Load Time	10 min	10 min	10 min	5 min	0 min	10 min
U-Turn Time	0 min	1.2 min	1.5 min	1 min	--	--
Max. Operating Time	1.7 hours	4 hours	4 hours	2.5 hours	100+ hours	20 hours
Dispersant Payload	240 gal	3,000 gal	2,170 gal	800 gal	3,000 gal	500 gal
Range of Doses	0.8-21.5 gal/acre	1.4-16.4 gal/acre	0.8-10.3 gal/acre	--	2.2-35.8 gal/acre	1.1-17.7 gal/acre
Source: NOAA Spill Tools (NOAA 1998)						

The estimated costs for dispersant applications with shoreline cleanup for high dispersant effectiveness (assumed to be 70% for heavy fuel oil and 80% for gasoline, diesel, and crude) and low dispersant effectiveness (assumed to by 35% for heavy fuel oil and 40% for gasoline, diesel, and crude) are shown in Tables 13 and 14 and Figures 101 and 102.

Table 13

Estimated Total Response Costs (With Dispersant Use) Lower Dispersant Efficiency						
Spill Scenario		Estimated Costs				
Oil Type	Scenario Percentile	Dispersant Application	Shoreline Cleanup[1,2] median/worst	Salvage/ Lightering	Spill Mgt.	Total Cost[2] median/worst
Diesel	20th	$85,000	$1,268,000	$9,000,000	$100,000	$10,453,000
			$2,576,000			$11,761,000
	50th	$476,000	$4,487,000	$9,000,000	$150,000	$14,113,000
			$1,061,000			$10,687,000
	95th	$2,562,000	$7,430,000	$9,000,000	$500,000	$19,492,000
			$10,292,000			$22,354,000
Gasoline	20th	$93,000	$16,000	$9,000,000	$85,000	$9,194,000
			$7,000			$9,185,000
	50th	$449,000	$122,000	$9,000,000	$110,000	$9,681,000
			$102,000			$9,661,000
	95th	$1,993,000	$327,000	$9,000,000	$325,000	$11,645,000
			$1,301,000			$12,619,000
Heavy Fuel Oil	20th	$70,000	$2,438,000	$5,000,000	$200,000	$7,708,000
			$3,933,000			$9,203,000
	50th	$198,000	$14,489,000	$5,000,000	$500,000	$20,187,000
			$24,518,000			$30,216,000
	95th	$632,000	$34,692,000	$5,000,000	$900,000	$41,224,000
			$63,370,000			$69,902,000
Crude	20th	$164,000	$5,826,000	$12,000,000	$500,000	$18,490,000
			$9,714,000			$22,378,000
	50th	$1,030,000	$17,322,000	$12,000,000	$1,000,000	$31,352,000
			$28,242,000			$42,272,000
	95th	$4,873,000	$50,472,000	$12,000,000	$4,000,000	$71,345,000
			$79,296,000			$100,169,000

[1]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use.
[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Table 14

Estimated Total Response Costs (With Dispersant Use) Higher Dispersant Efficiency						
Spill Scenario		Estimated Costs				
Oil Type	Scenario Percentile	Dispersant Application	Shoreline Cleanup[1,2] median/worst	Salvage/ Lightering	Spill Mgt.	Total Cost[2] median/worst
Diesel	20th	$85,000	$422,600	$9,000,000	$100,000	$9,608,000
			$858,600			$10,044,000
	50th	$476,000	$1,495,800	$9,000,000	$150,000	$11,122,000
			$353,800			$9,980,000
	95th	$2,562,000	$2,476,600	$9,000,000	$500,000	$14,539,000
			$3,430,600			$15,493,000
Gasoline	20th	$93,000	$5,200	$9,000,000	$85,000	$9,183,000
			$2,400			$9,180,000
	50th	$449,000	$40,800	$9,000,000	$110,000	$9,600,000
			$34,000			$9,593,000
	95th	$1,993,000	$109,000	$9,000,000	$325,000	$11,427,000
			$433,600			$11,752,000
Heavy Fuel Oil	20th	$70,000	$1,125,000	$5,000,000	$200,000	$6,395,000
			$1,815,000			$7,085,000
	50th	$198,000	$6,687,000	$5,000,000	$500,000	$12,385,000
			$11,316,000			$17,014,000
	95th	$632,000	$16,011,600	$5,000,000	$900,000	$22,544,000
			$29,247,600			$35,780,000
Crude	20th	$164,000	$1,942,000	$12,000,000	$500,000	$14,606,000
			$3,238,000			$15,902,000
	50th	$1,030,000	$5,774,000	$12,000,000	$1,000,000	$19,804,000
			$9,414,000			$23,444,000
	95th	$4,873,000	$16,824,000	$12,000,000	$4,000,000	$37,697,000
			$26,432,000			$47,305,000

[1]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use.
[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Figure 101

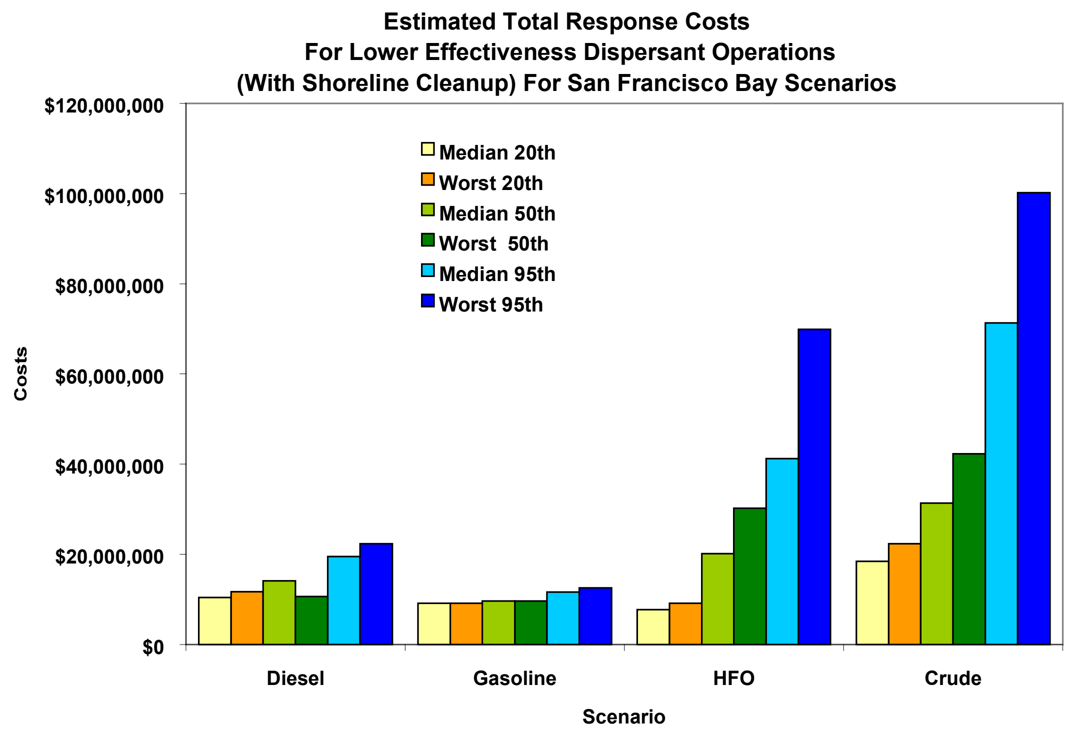
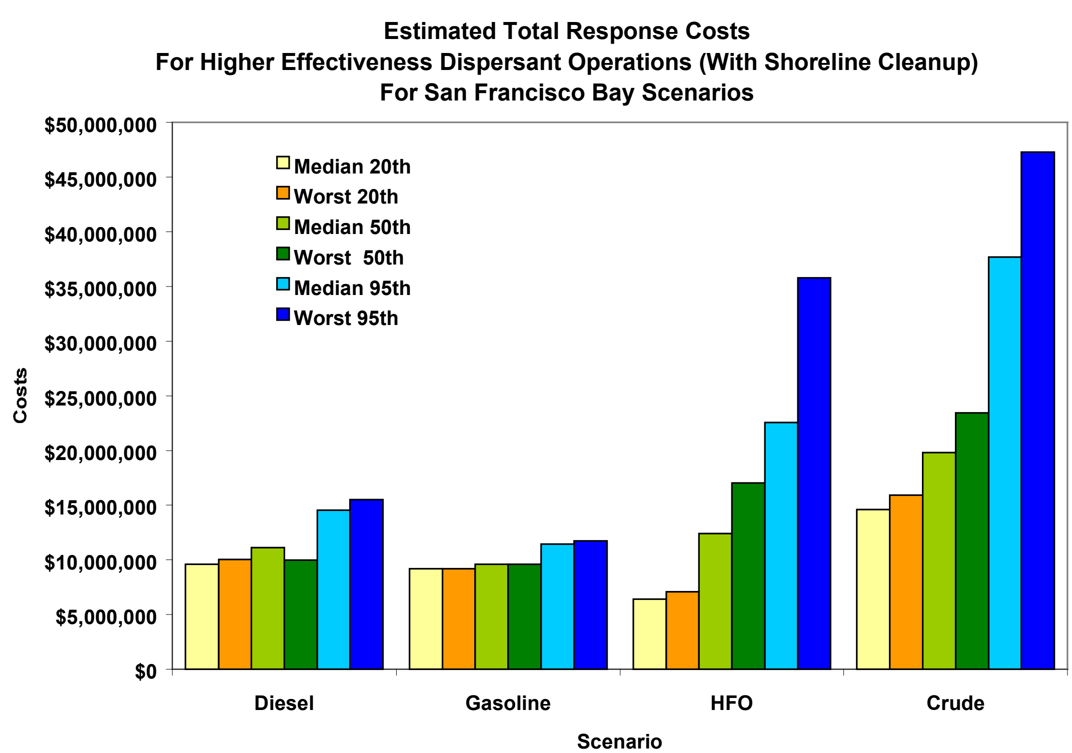


Figure 102



7.0 Comparison Between Mechanical Recovery- and Dispersant-Strategy Operations Costs

A comparison between the total response costs (including on-water and shoreline response costs) for operations with primary on-water mechanical recovery strategies and operations with primary on-water dispersant application strategies is shown in Table 15.

Dispersant responses were broken down into two categories depending on the effectiveness of the dispersants. “Low dispersant effectiveness” refers to situations in which the dispersant chemical application effectively dispersed 35% of the heavy fuel and 40% of the diesel, gasoline, or crude oil. “High dispersant effectiveness” refers to situations in which the dispersant chemical application effectively dispersed 70% of the heavy fuel and 80% of the diesel, gasoline, or crude oil.

The total costs for on-water and shoreline response operations in which dispersant application is the primary on-water response operation is considerably lower than the costs for operations in which mechanical recovery is the primary on-water response strategy. This is particularly true for larger spills and for the more persistent oils (HFO, crude, and to a lesser extent, diesel). Smaller spills are less impacted by the cost reduction since the costs for initialization of the response (mobilization) is realized even at very low spill levels. (If fact, these costs could be incurred if there were a significant *threat* of a spill without any ultimate spillage.) The costs for gasoline spills are impacted only slightly if at all since the shoreline cleanup response operations for these spills are relatively minor since little gasoline impacts the shoreline and relatively little can be done to remove the gasoline when it does impact shoreline areas.

The percentage reduction of costs with the use of dispersants is shown in Table 16.

Table 15

Comparison Between Total On-Water and Shoreline Response Costs For Responses With Primary Mechanical Recovery and Dispersant Strategies				
Oil Type	**Scenario[1]**	**Response Costs By Primary On-Water Response Strategy**		
		Mechanical Operations	**Dispersant Operations** ***Lower Effectiveness[2]***	**Dispersant Operations** ***Higher Effectiveness[3]***
Diesel	Median 20th	$12,205,500	$10,453,000	$9,608,000
	Worst 20th	$14,385,500	$11,761,000	$10,044,000
	Median 50th	$18,788,500	$14,113,000	$11,122,000
	Worst 50th	$13,078,500	$10,687,000	$9,980,000
	Median 95th	$26,894,500	$19,492,000	$14,539,000
	Worst 95th	$31,664,500	$22,354,000	$15,493,000
Gasoline	Median 20th	$10,021,000	$9,194,000	$9,183,000
	Worst 20th	$10,007,000	$9,185,000	$9,180,000
	Median 50th	$11,044,000	$9,681,000	$9,600,000
	Worst 50th	$11,010,000	$9,661,000	$9,593,000
	Median 95th	$13,402,000	$11,645,000	$11,427,000
	Worst 95th	$15,025,000	$12,619,000	$11,752,000
HFO	Median 20th	$11,619,000	$7,708,000	$6,395,000
	Worst 20th	$13,919,000	$9,203,000	$7,085,000
	Median 50th	$35,107,000	$20,187,000	$12,385,000
	Worst 50th	$50,537,000	$30,216,000	$17,014,000
	Median 95th	$78,087,000	$41,224,000	$22,544,000
	Worst 95th	$122,207,000	$69,902,000	$35,780,000
Crude	Median 20th	$29,549,000	$18,490,000	$14,606,000
	Worst 20th	$36,029,000	$22,378,000	$15,902,000
	Median 50th	$65,498,000	$31,352,000	$19,804,000
	Worst 50th	$83,698,000	$42,272,000	$23,444,000
	Median 95th	$182,144,000	$71,345,000	$37,697,000
	Worst 95th	$230,184,000	$100,169,000	$47,305,000

[1]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.
[2]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use.
[3]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use.

Table 16

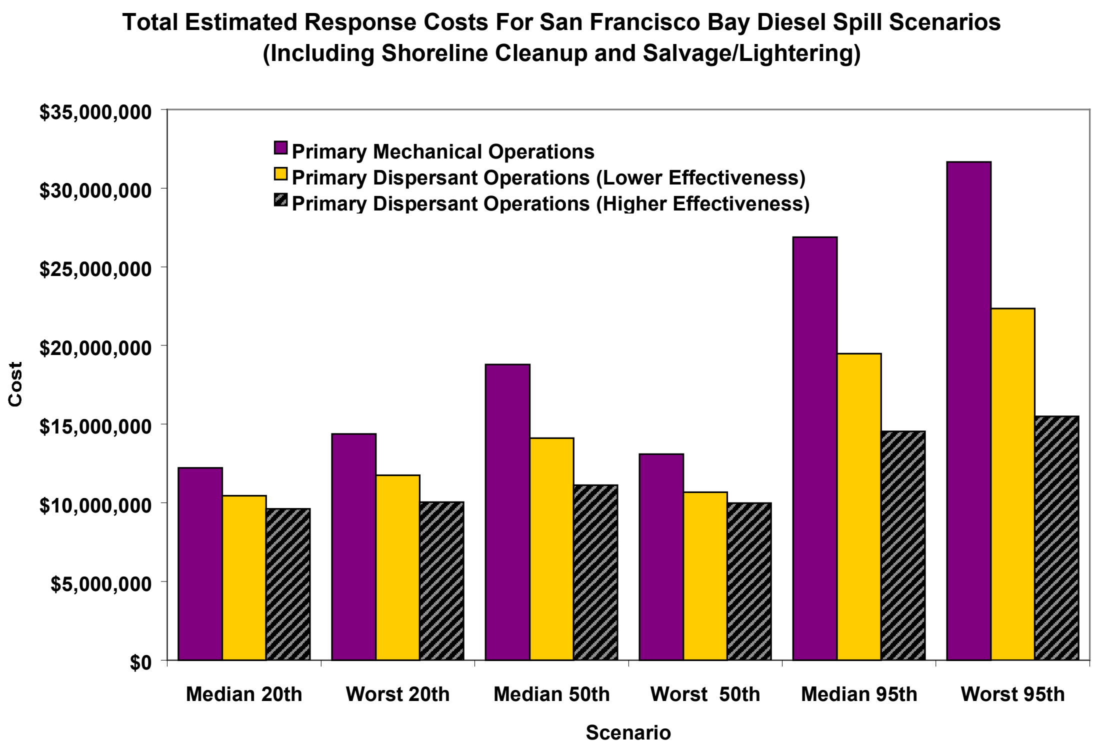
Percentage Reduction Of Total Response Costs From Use of Dispersant Application Strategies Instead of Mechanical Recovery Strategy Operations			
Oil Type	**Scenario[1]**	**Percentage Reduction Of Total Response Costs**	
		Dispersant Operations ***Lower Effectiveness*[2]**	**Dispersant Operations** ***Higher Effectiveness*[3]**
Diesel	Median 20th	14%	21%
	Worst 20th	18%	30%
	Median 50th	25%	41%
	Worst 50th	18%	24%
	Median 95th	28%	46%
	Worst 95th	29%	51%
Gasoline	Median 20th	8%	8%
	Worst 20th	8%	8%
	Median 50th	12%	13%
	Worst 50th	12%	13%
	Median 95th	13%	15%
	Worst 95th	16%	22%
HFO	Median 20th	34%	45%
	Worst 20th	34%	49%
	Median 50th	42%	65%
	Worst 50th	40%	66%
	Median 95th	47%	71%
	Worst 95th	43%	71%
Crude	Median 20th	37%	51%
	Worst 20th	38%	56%
	Median 50th	52%	70%
	Worst 50th	49%	72%
	Median 95th	61%	79%
	Worst 95th	56%	79%

[1]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.
[2]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use.
[3]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use.

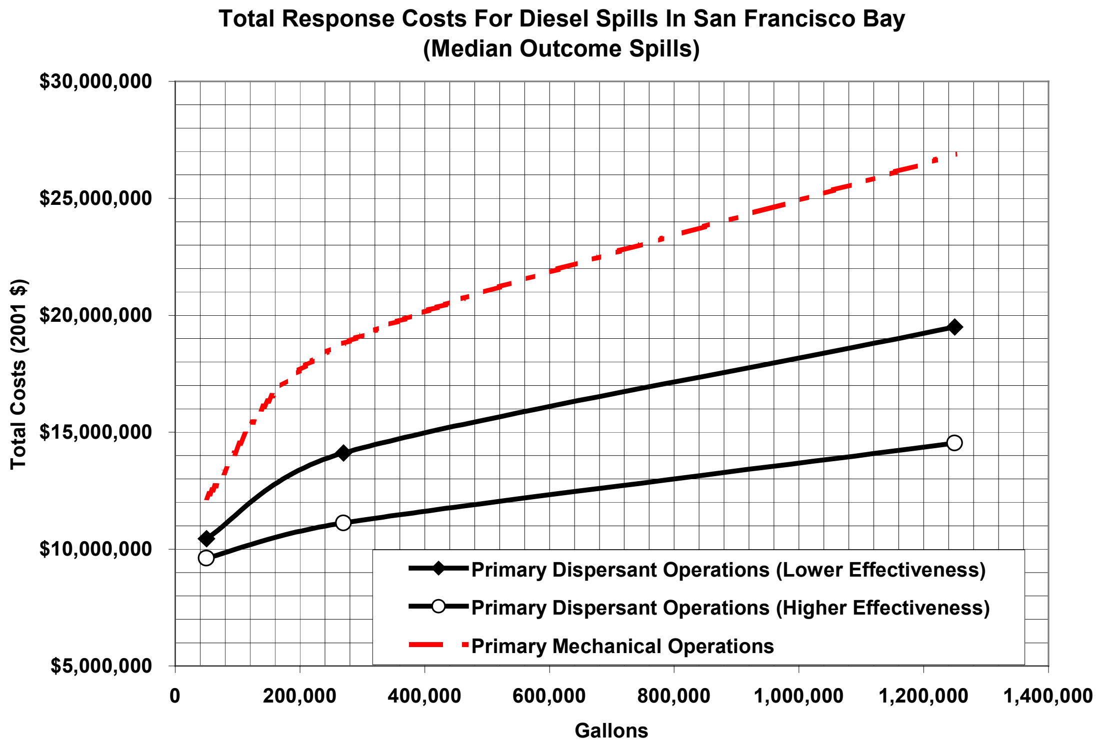
7.1 Comparison of Response Costs By Strategy for Diesel Spills

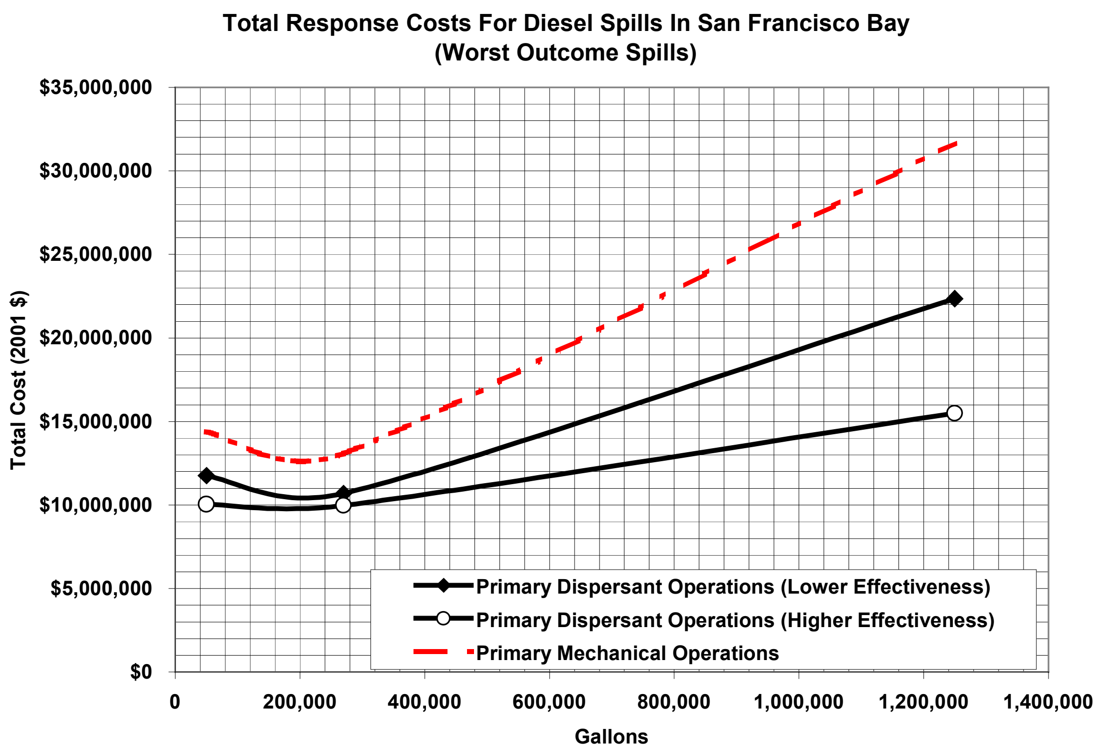
Total estimated response costs for the diesel spill scenarios are compared by primary on-water response strategy as shown in Figures 103-105. Per-gallon response costs for the different response strategies are shown in Figures 106 and 107. Per-gallon costs decline with the larger spill sizes. Smaller spills require an initial mobilization and similar costs to the response operations in larger spills.

Figure 103

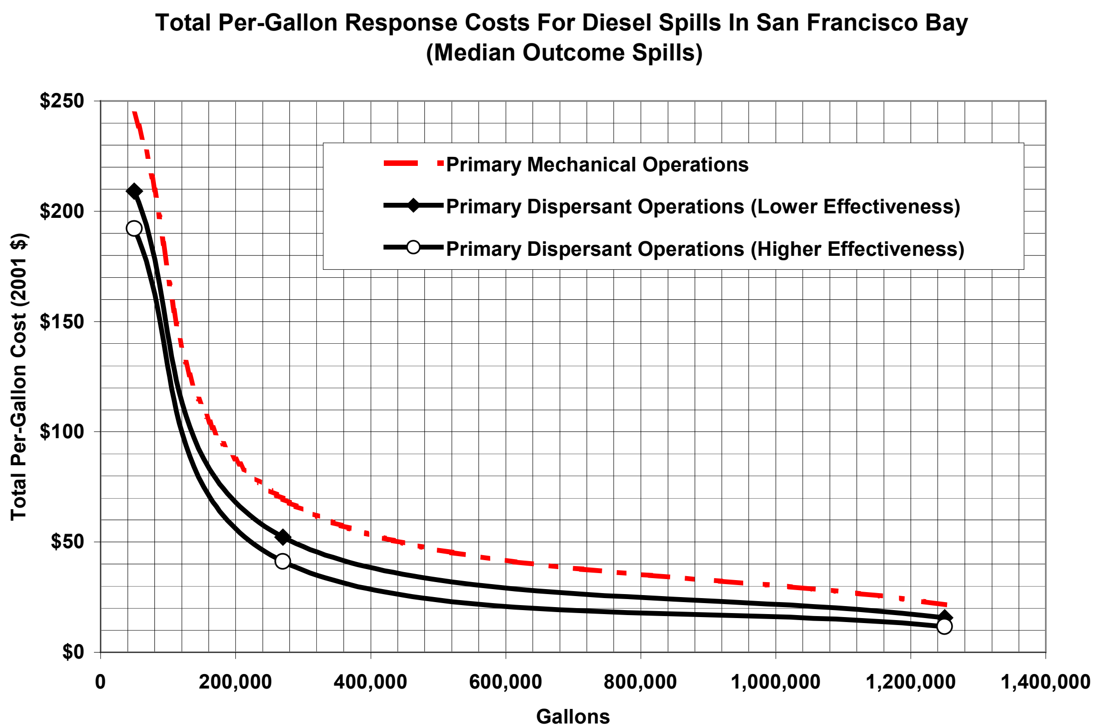


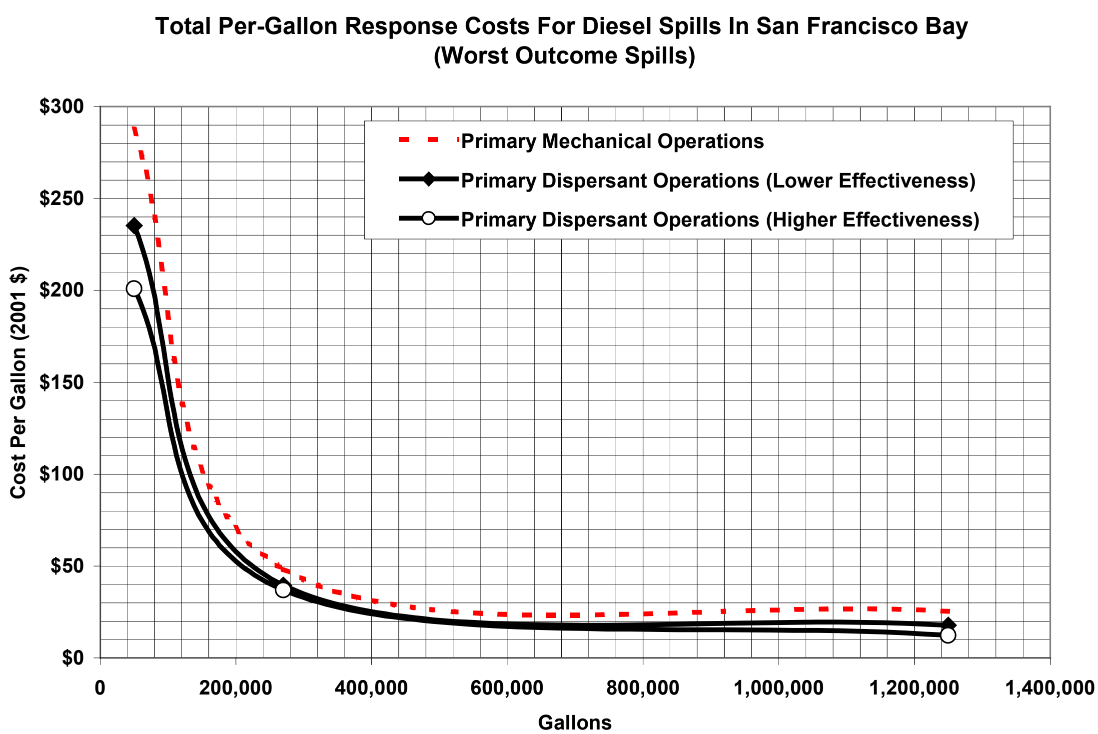
Figures 104 and 105





Figures 106 and 107

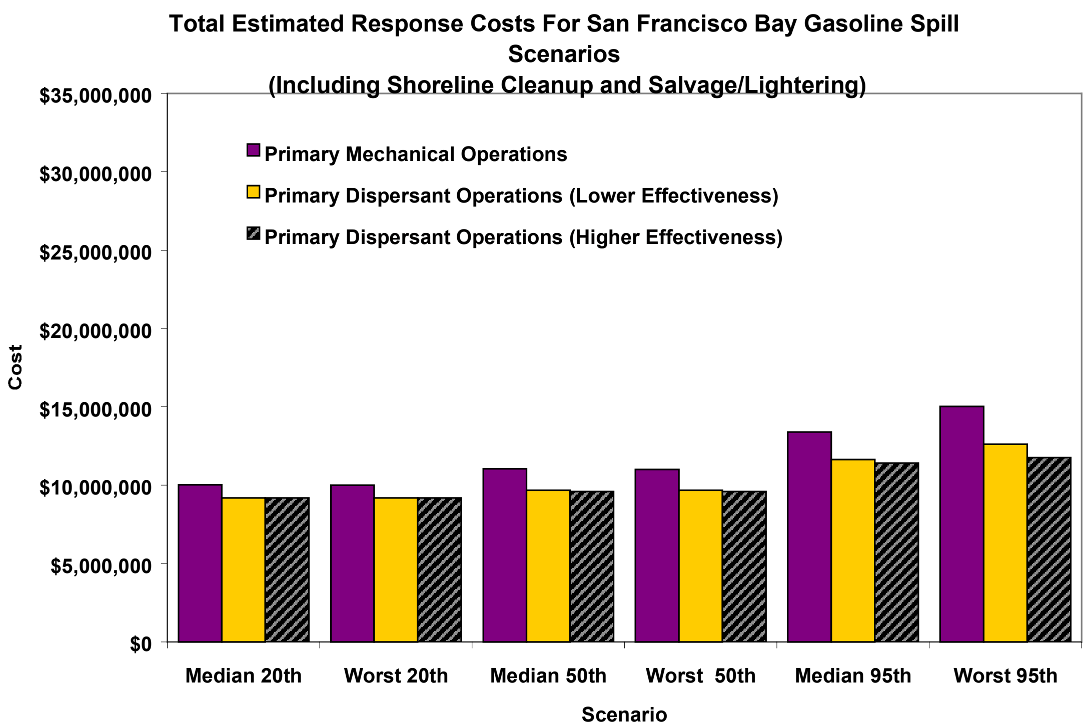




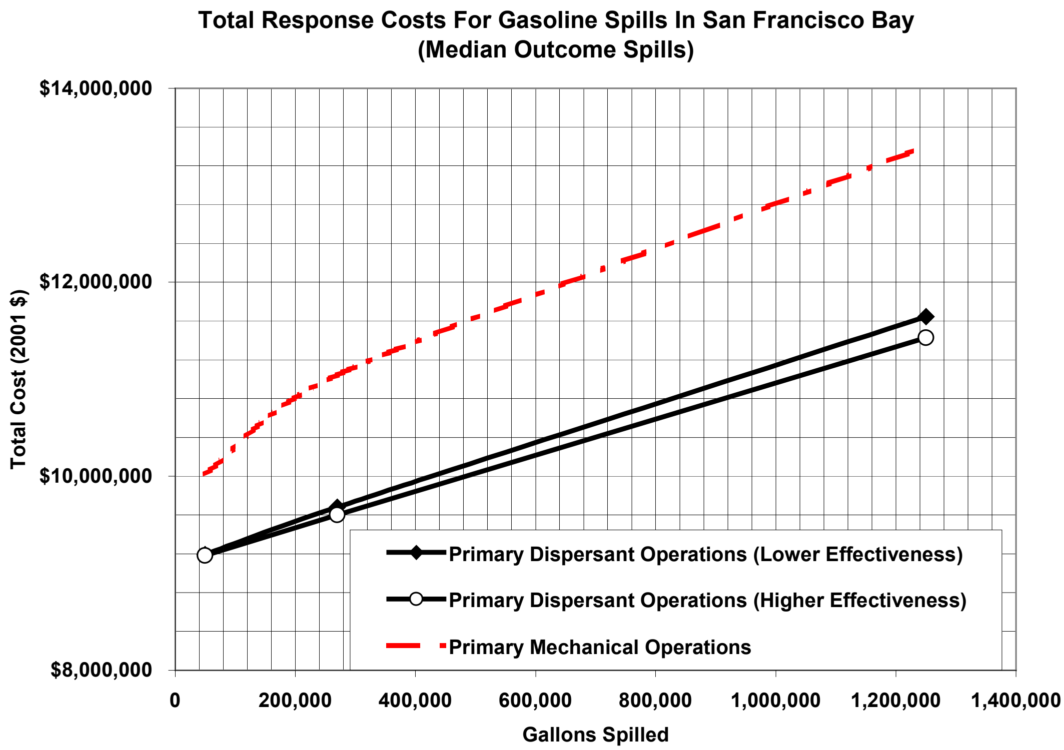
7.2 Comparison of Response Costs By Strategy for Gasoline Spills

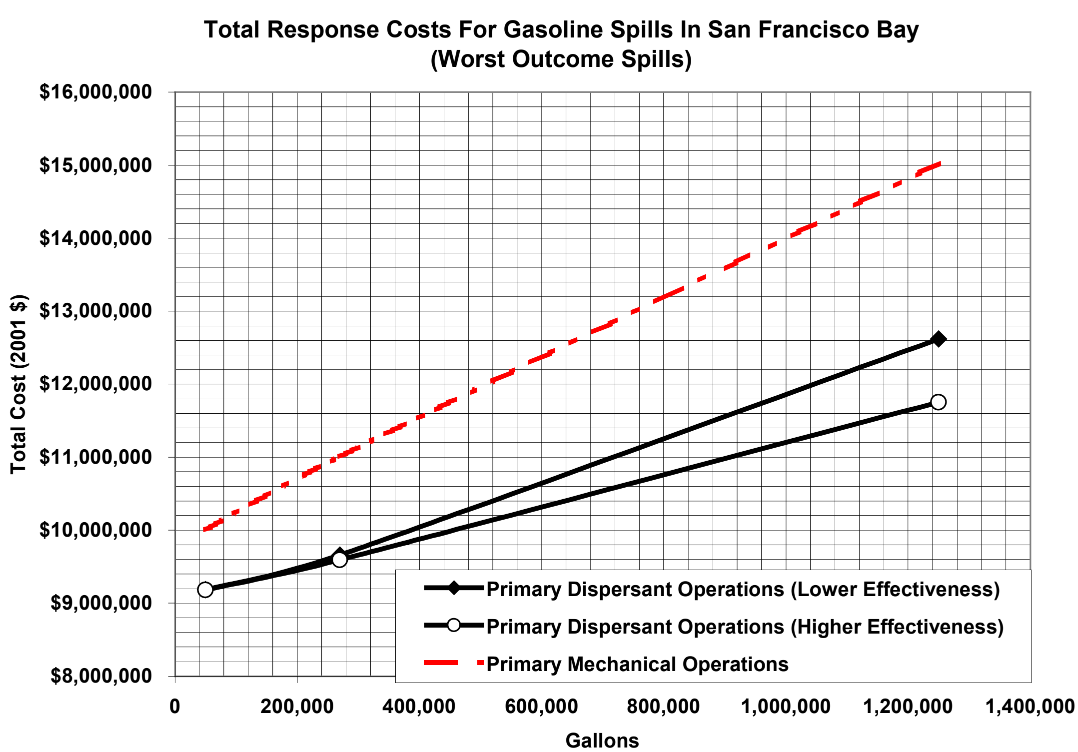
Total estimated response costs for the gasoline spill scenarios are compared by primary on-water response strategy as shown in Figures 108-110. Per-gallon response costs for the different response strategies are shown in Figures 111 and 112. For gasoline spills the differences between the response strategies are less pronounced. Differences between smaller and larger spills are also less pronounced. This is because the shoreline response component of the entire response operations – both for mechanical recovery-based operations and dispersant-based operations – is much lower since less oil impacts the shoreline. Gasoline tends to evaporate and disperse rather than strand on shoreline areas. Even when the shorelines are impacted, relatively little can be done but wait for natural cleansing to occur through wave action and oil weathering.

Figure 108

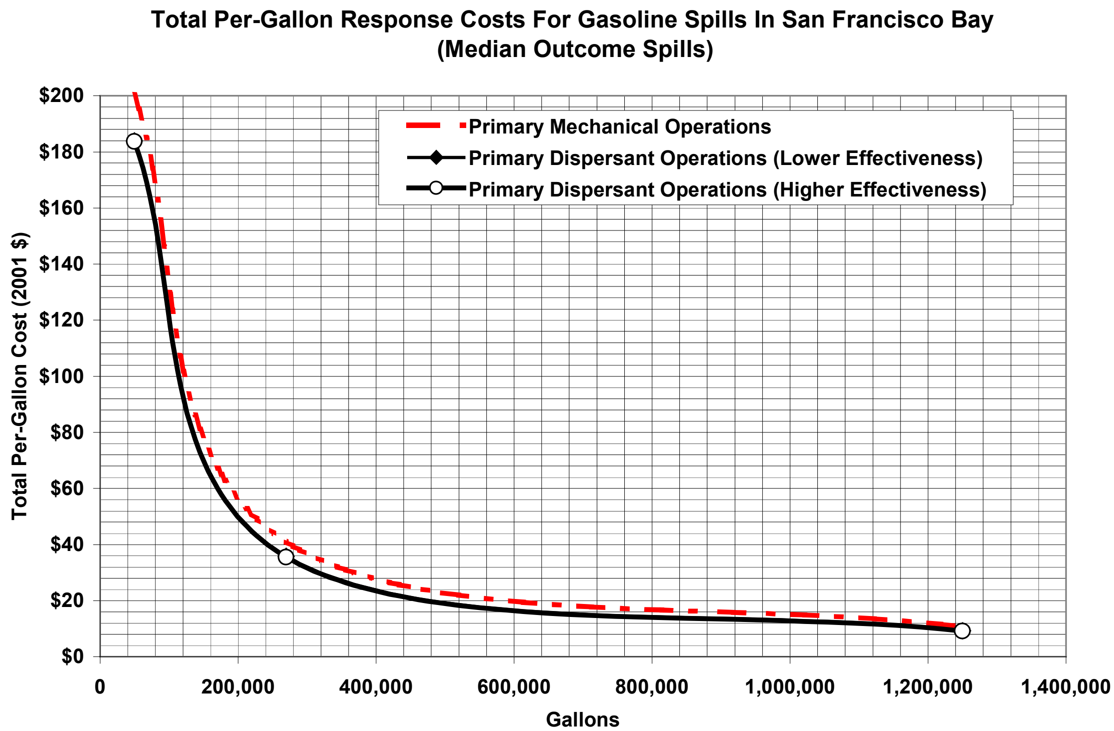


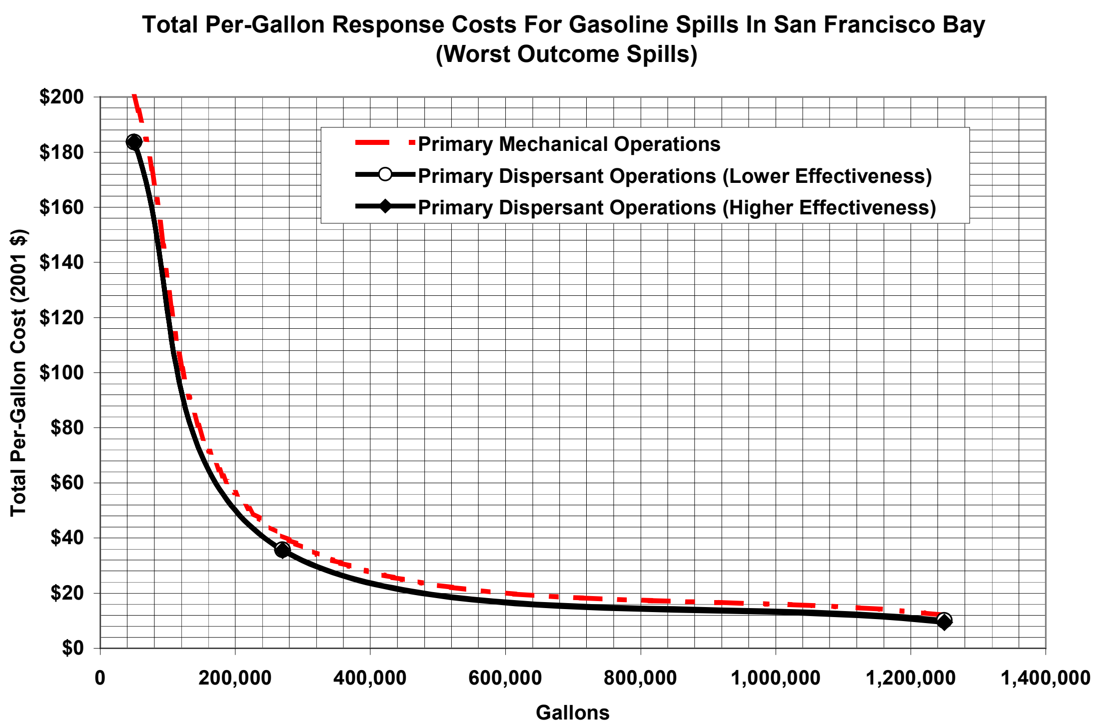
Figures 109 and 110





Figures 111 and 112

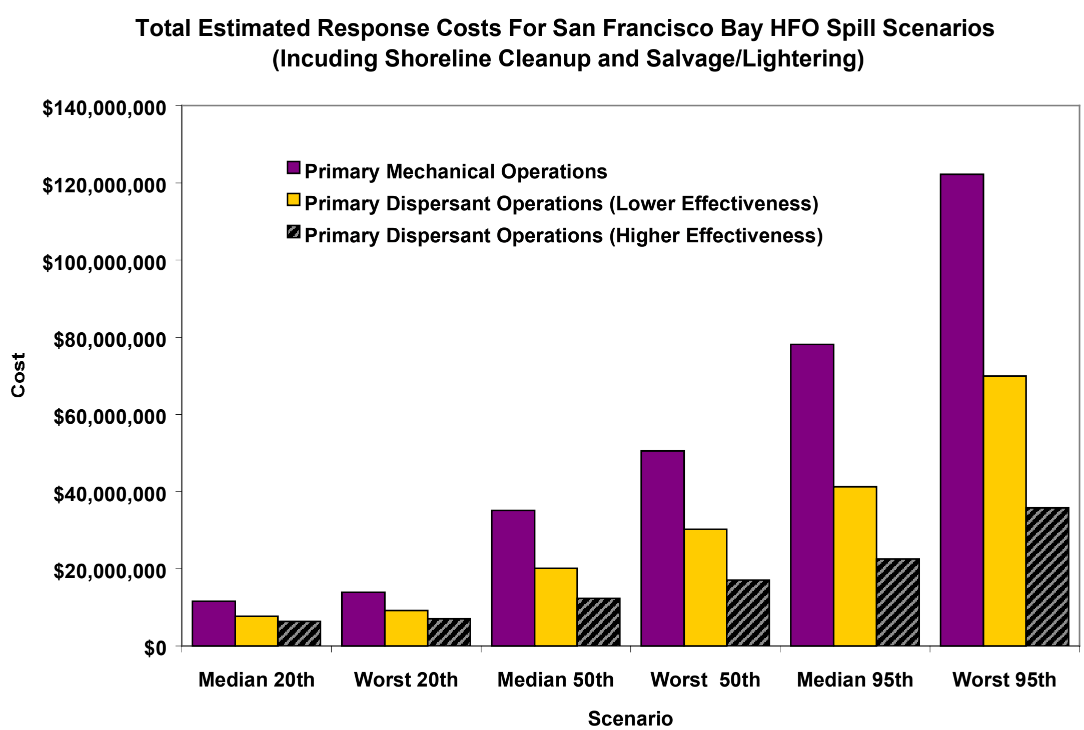




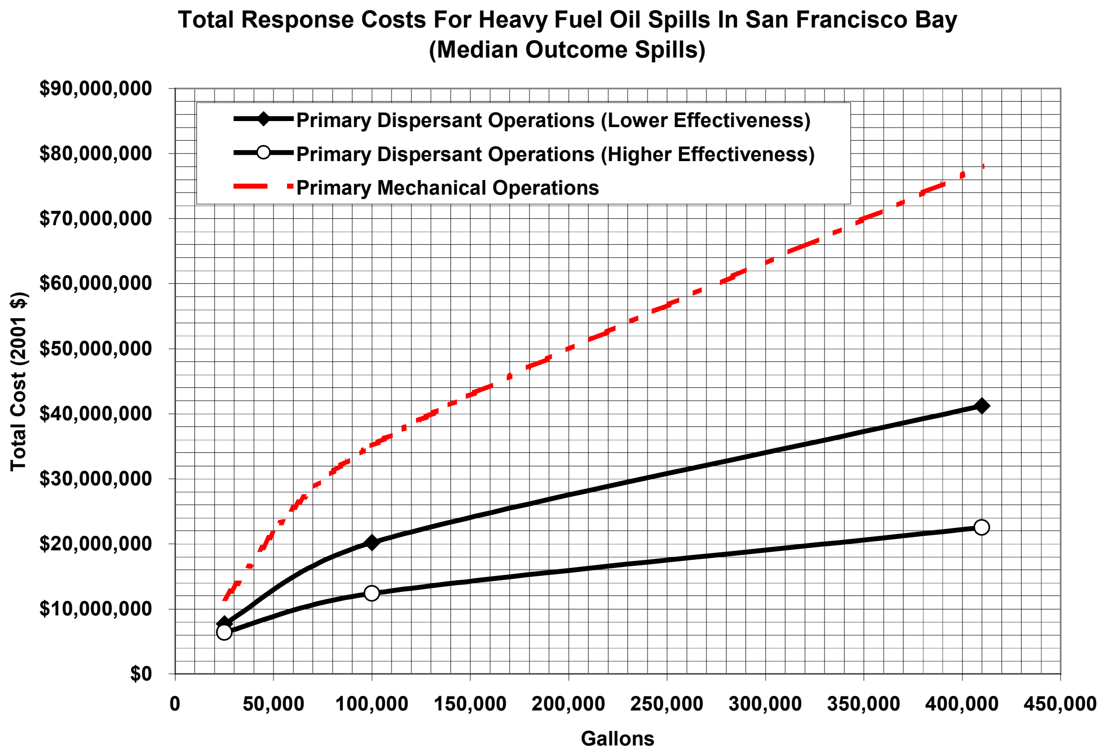
7.3 Comparison of Response Costs By Strategy for Heavy Fuel Oil Spills

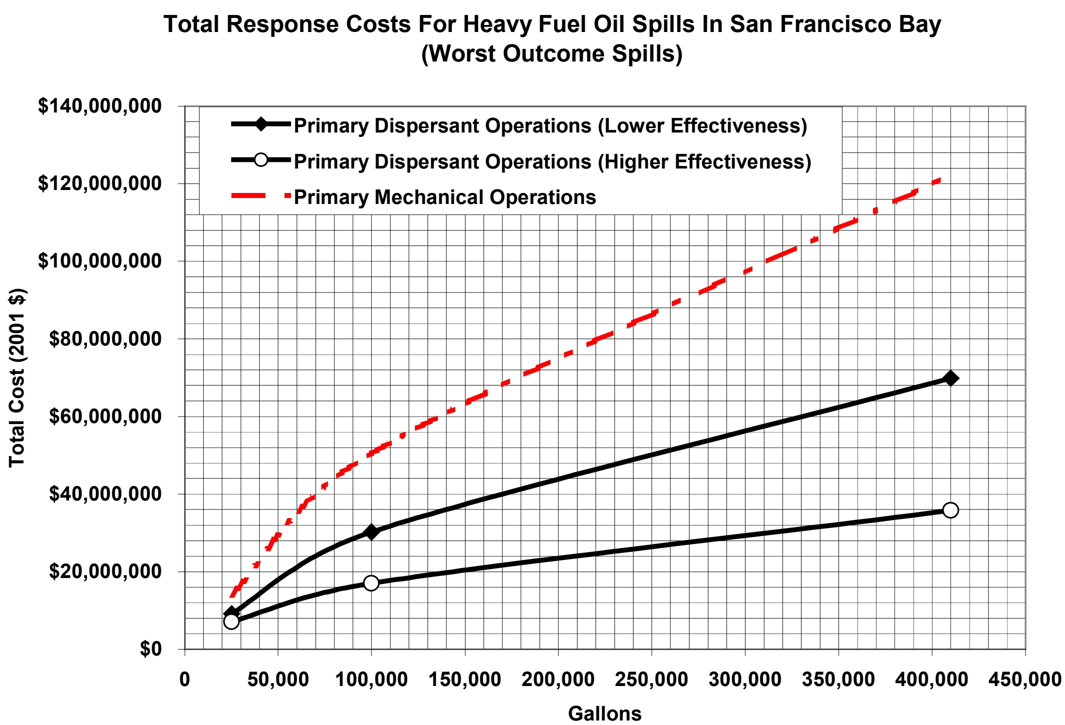
Total estimated response costs for the heavy fuel oil spill scenarios are compared by primary on-water response strategy as shown in Figures 113-115. Per-gallon response costs for the different response strategies are shown in Figures 116 and 117. Per-gallon costs decline with the larger spill sizes. Smaller spills require an initial mobilization and similar costs to the response operations in larger spills.

Figure 113

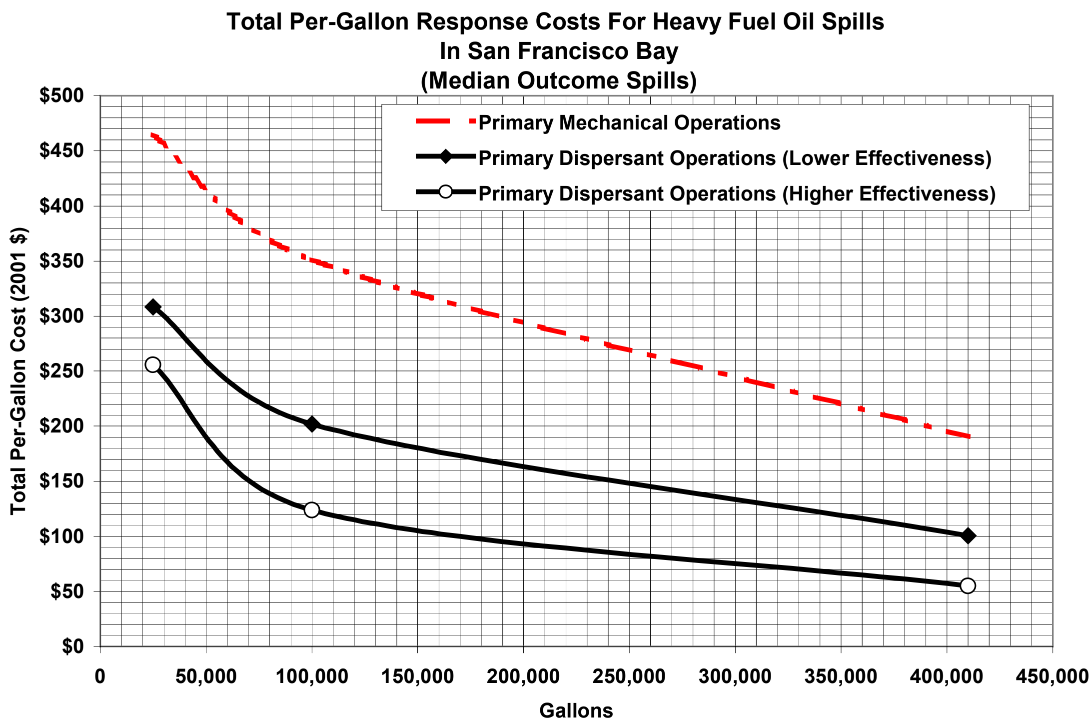


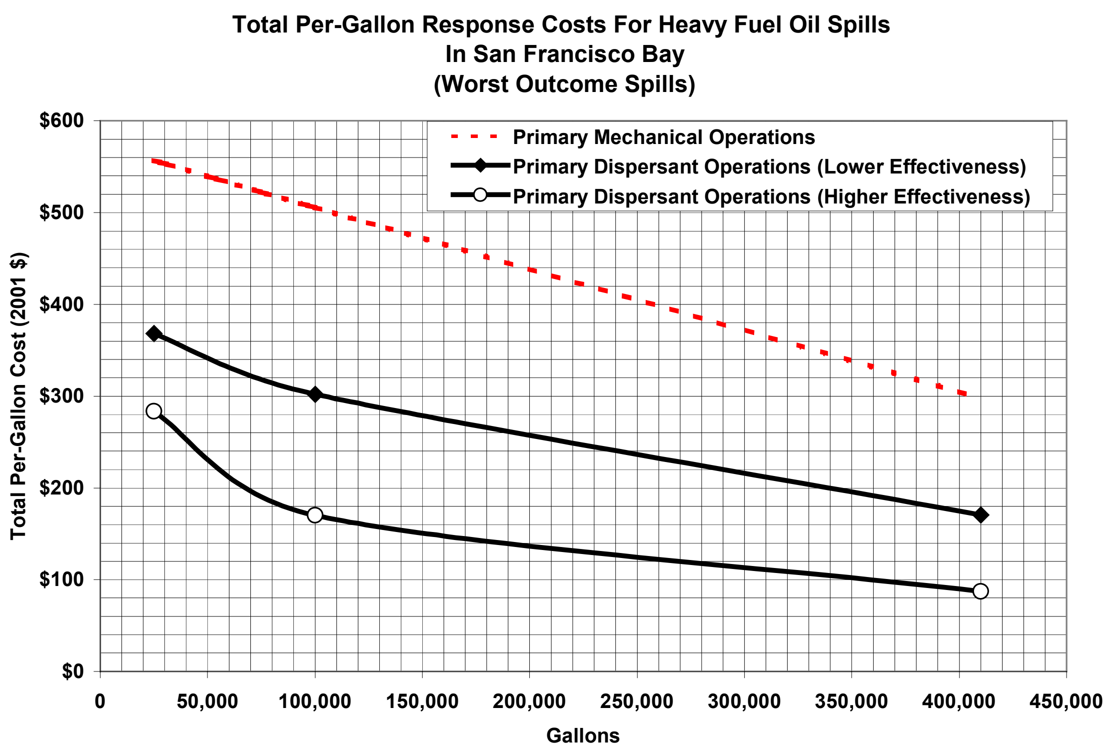
Figures 114 and 115





Figures 116 and 117

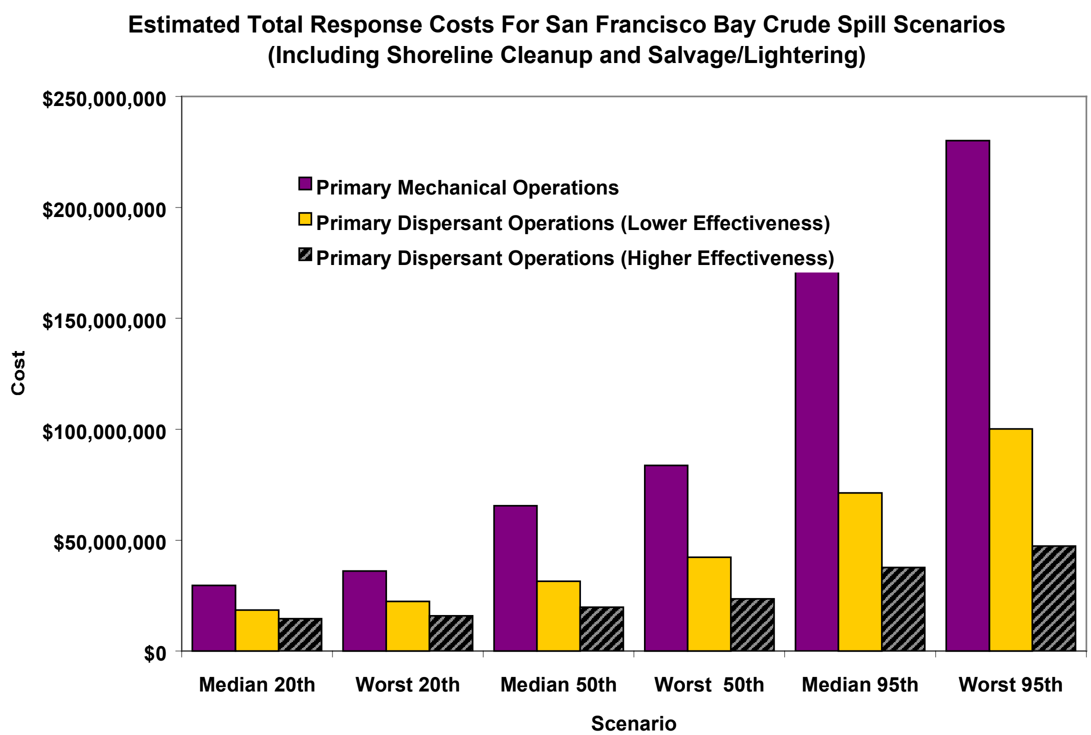




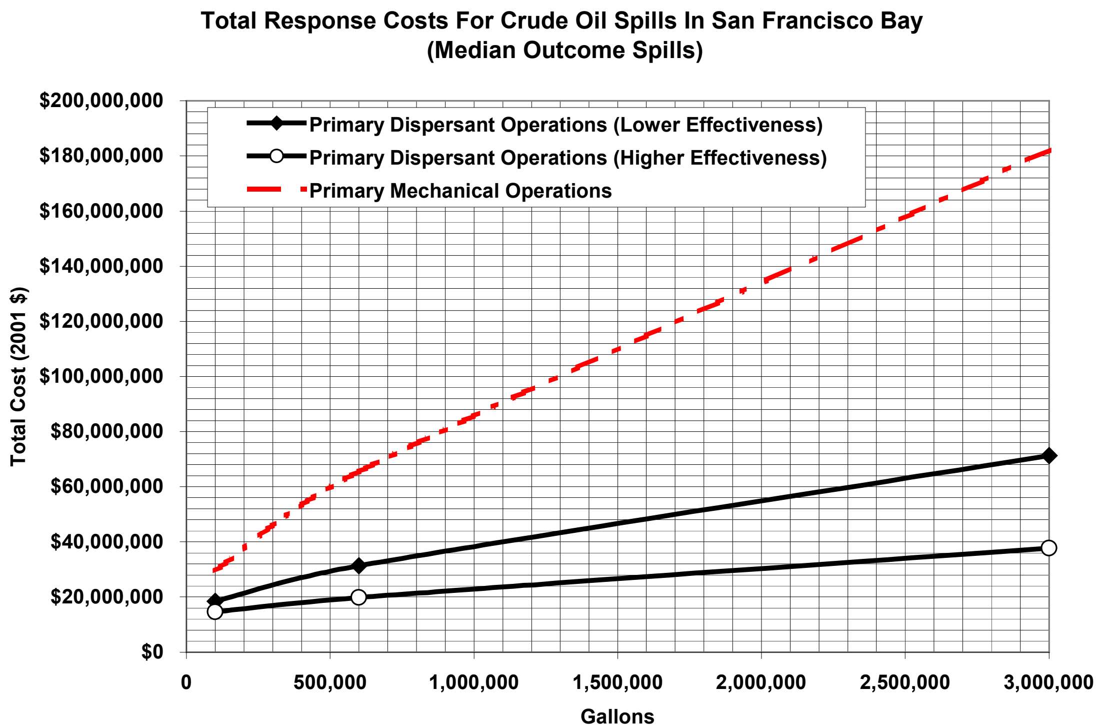
7.4 Comparison of Response Costs By Strategy for Crude Spills

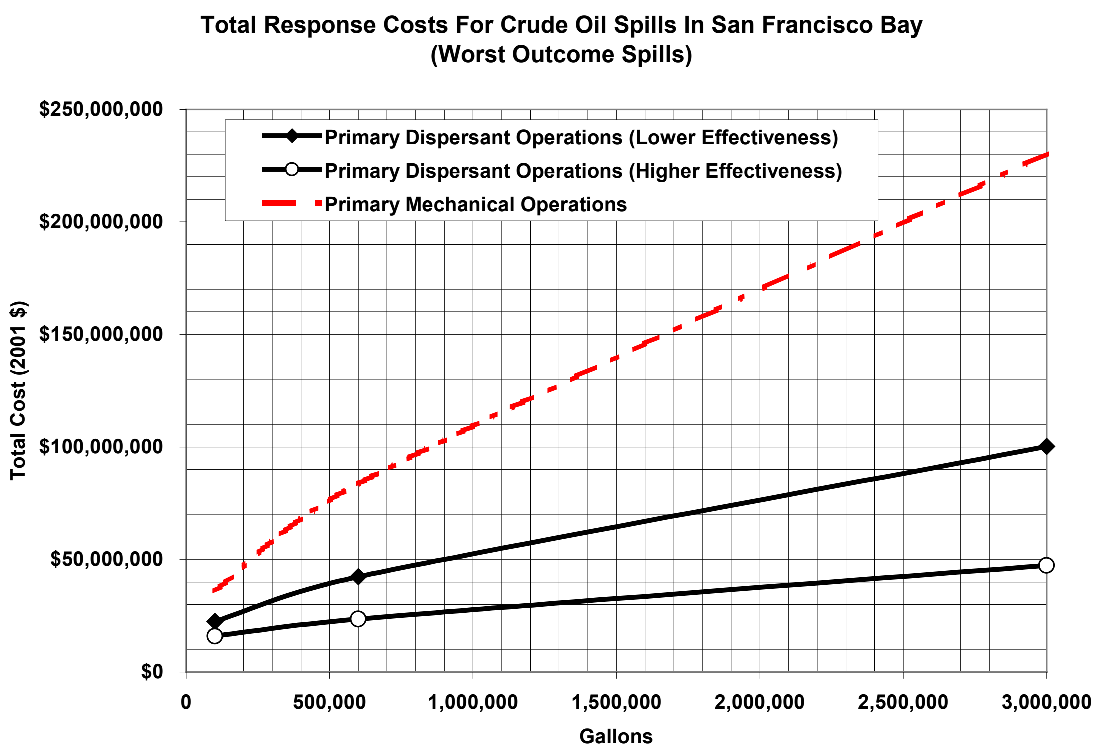
Total estimated response costs for the crude oil spill scenarios are compared by primary on-water response strategy as shown in Figures 118-120. Per-gallon response costs for the different response strategies are shown in Figures 121 and 122. Per-gallon costs decline with the larger spill sizes. Smaller spills require an initial mobilization and similar costs to the response operations in larger spills.

Figure 118

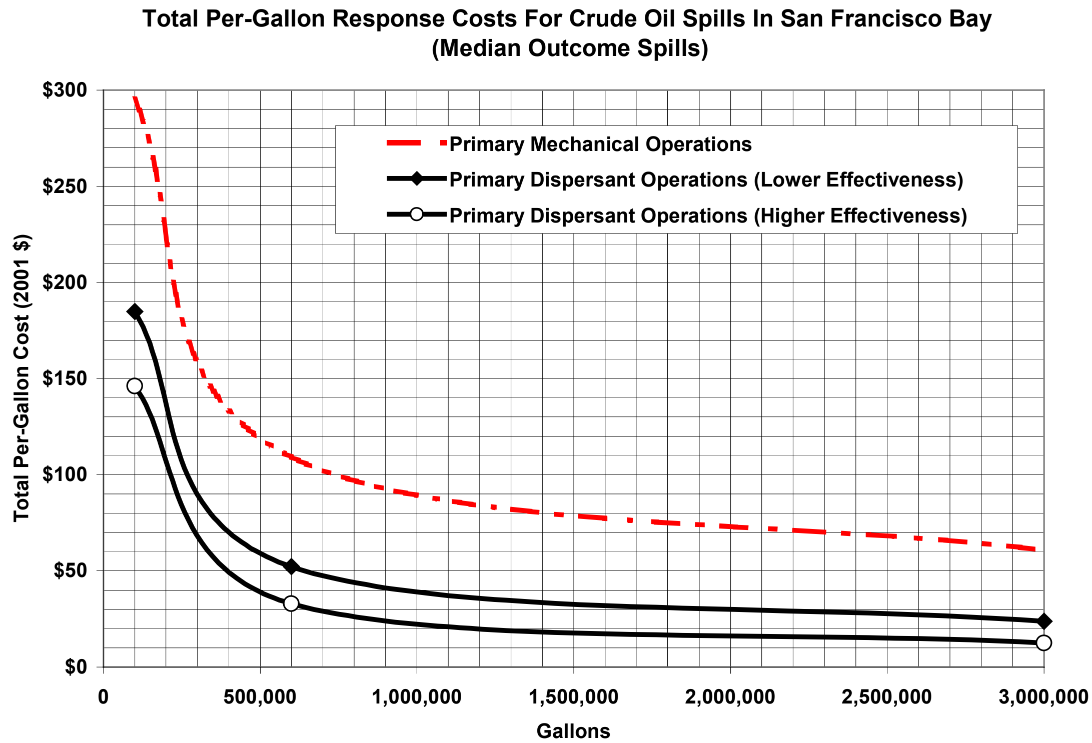


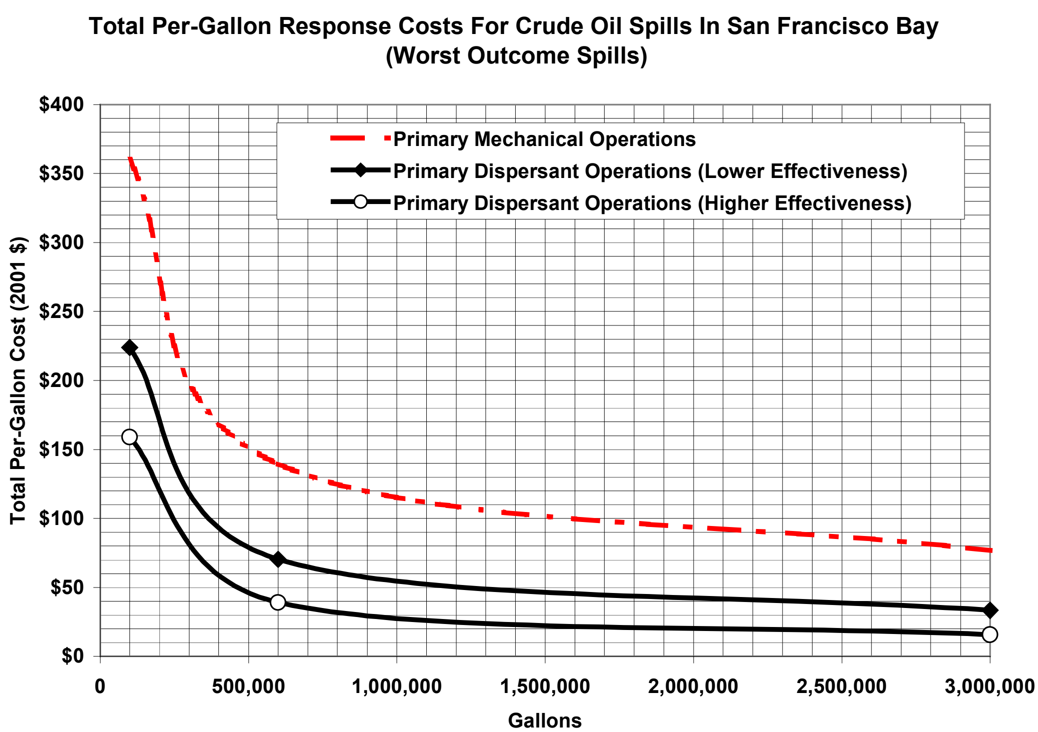
Figures 119 and 120





Figures 121 and 122





8.0 Future Cost Projections (to Year 2010)

Estimated cost projections to future years – through 2010 – were made based on US Consumer Price Index projections (see Appendix A). All cost projections assume that prices will follow the inflation and dollar devaluation rate shown in Appendix A. Significant changes in future dollar values that deviate from this course cannot be predicted and are not accounted for in the future cost projections.

In making future cost projections for response operations, it is also assumed that the costs in all categories (e.g., labor, equipment, logistical costs) will increase at the same rate. It is assumed that there no significant improvements in response technology are introduced that would drastically reduce any component of response costs (e.g., dispersant chemicals that are a fraction of the price of current formulations or mechanized shoreline cleanup devices that drastically reduce the labor force currently required.)

Estimated total response costs (including on-water and shoreline costs, disposal, salvage and lightering, and spill management costs) for responses with primary on-water mechanical recovery strategies for the years 2001 through 2010 are shown in Appendix D. The same costs calculated as *per-gallon costs* are also shown in Appendix D.

Likewise, estimated total response costs and per-gallon costs (including on-water and shoreline costs, disposal, salvage and lightering, and spill management costs) for responses with primary dispersant application strategies with lower- and higher-dispersant efficiency assumptions are shown Appendix D.

As time progresses through this decade, there will be a greater likelihood of chemical dispersion being a viable *primary* response strategy option for oil spills in San Francisco Bay. There will also be a greater likelihood of increased *effectivenes*s of dispersant application in the future. (See Table 17.) Operational hurdles will be overcome with greater preparation and training, as well as field experience. Better dispersant chemicals may be developed as research and development in this area accelerates with greater interest in the use of dispersants by response officials and planners.

The ensuing effect of evolving response strategies and efficiencies on response costs is not completely straightforward. Even with increasing reliance on dispersants, it is unlikely that dispersants will ever be the *only* strategy, however, particularly in spills exceeding 500,000 gallons of input. Response operations for larger spills will tend to involve a *combination* of strategies since dispersant usage may be pre-empted in certain environmentally-sensitive locations. In some situations, logistical issues may make dispersant use impractical (e.g., unavailability of requisite aircraft or weather conditions that preempt flying). (See Table 18 for recommendations for factoring in the relative weight of efforts and costs for dispersant- and mechanical recovery-based operations in the future.)

Response operations involving *both* extensive mechanical recovery operations *and* dispersant operations would tend to be higher in cost than those involving dispersant application alone. The costs for complex, dual-strategy spill responses may actually *exceed* those for strict mechanical recovery operations since non-redundant equipment and personnel for both mechanical and dispersant operations need to be mobilized (Etkin 1998*b*).

The projected future response costs for the *smaller* San Francisco Bay oil spills (under 100,000 gallons) will probably be closer to the costs for lower-efficiency dispersant operations during the middle of the decade and for higher-efficiency dispersant operations towards 2010. Response costs for the medium to larger spills will likely also approach those of lower- and then higher-efficiency dispersant operations towards the end of this decade. The 95th percentile spills will still likely involve both mechanical and dispersant operations with costs that tend toward the higher mechanical recovery operation costs.

Table 17

Projected Response Cost Basis[1]
[Based on On-Water Response Strategy Options]

Scenario Percentile	Spill Volume (gallons)	Time Period		
		Present (2002 –2004)	2005 – 2007[2]	2008 – 2010[2]
20th	**<100,000**	*Mechanical only*	*Dispersant (low-effect.) + Mechanical*	*Dispersant (high-effect.) + Mechanical*
50th	**100,000 – 500,000**	*Mechanical only*	*Dispersant (low effect.) + Mechanical*	*Dispersant (high effect.) + Mechanical*
95th	**>500,000**	*Mechanical only*	*Dispersant (low effect.) + Mechanical*	*Dispersant (high effect.) + Mechanical*

[1]Cost basis refers to cost estimations made for on-water response strategies (including all associated shoreline operations costs) employing mechanical containment and recovery and dispersant application (with low- and high-effectiveness) as described in Sections 6 and 7 of this report.
[2]Recommendations for factoring in the relative weight of mechanical and dispersant application efforts and resultant costs are shown in Table 18.

Table 18

Relative Weighting Of Mechanical And Dispersant Application Efforts For Typical Post-2004 Spill Responses[1,2]						
Volume (gallons)	Year					
	2005	2006	2007	2008	2009	2010
<100,000	$0.8D_l + 0.2M$	$0.85D_l + 0.15M$	$0.9D_l + 0.1M$	$0.9D_h + 0.1M$	$0.95D_h + 0.05M$	$0.99D_h + 0.01M$
100,000 – 500,000	$0.7D_l + 0.3M$	$0.75D_l + 0.25M$	$0.8D_l + 0.2M$	$0.8D_h + 0.2M$	$0.85D_h + 0.15M$	$0.9D_h + 0.1M$
>500,000	$0.6D_l + 0.4M$	$0.7D_l + 0.3M$	$0.75D_l + 0.25M$	$0.75D_h + 0.25M$	$0.8D_h + 0.2M$	$0.85D_h + 0.15M$

[1]D_l = low-effectiveness dispersant application effort; D_h = high-effectiveness dispersant application effort; M = mechanical containment and recovery effort
[2]The equations presented refer to the weighting of the relative *effort* from each of the response strategies. The estimated *costs* associated these response efforts (for spill responses that occur between 2005 and 2010 are shown in Tables 19 and 20.

Table 19

Total Estimated Response Costs For Oil Spills in San Francisco Bay Based on Most Probable Response Methodologies[1] 2001 - 2005							
Scenario			Total Projected Response Costs[2]				
Oil Type	Percentile	Shoreline Impact	2001	2002	2003	2004	2005
Diesel	20th	*median*	$12,205,500	$12,511,000	$12,840,000	$13,158,000	$11,948,600
		worst	$14,385,500	$14,745,000	$15,134,000	$15,508,000	$13,588,400
	50th	*median*	$18,788,500	$19,258,000	$19,766,000	$20,254,000	$17,160,300
		worst	$13,078,500	$13,405,000	$13,759,000	$14,099,000	$12,613,500
	95th	*median*	$26,894,500	$27,567,000	$28,293,000	$28,992,000	$24,832,800
		worst	$31,664,500	$32,456,000	$33,311,000	$34,134,000	$28,842,800
Gasoline	20th	*median*	$10,021,000	$10,272,000	$10,542,000	$10,803,000	$10,351,800
		worst	$10,007,000	$10,257,000	$10,527,000	$10,788,000	$10,340,800
	50th	*median*	$11,044,000	$11,320,000	$11,618,000	$11,905,000	$11,159,400
		worst	$11,010,000	$11,285,000	$11,583,000	$11,869,000	$11,132,600
	95th	*median*	$13,402,000	$13,737,000	$14,099,000	$14,447,000	$13,656,600
		worst	$15,025,000	$15,401,000	$15,806,000	$16,197,000	$15,021,400
Heavy Fuel Oil	20th	*median*	$11,619,000	$11,909,000	$12,223,000	$12,525,000	$9,390,200
		worst	$13,919,000	$14,267,000	$14,643,000	$15,005,000	$11,222,000
	50th	*median*	$35,107,000	$35,985,000	$36,933,000	$37,845,000	$27,277,300
		worst	$50,537,000	$51,800,000	$53,165,000	$54,479,000	$40,161,500
	95th	*median*	$78,087,000	$80,039,000	$82,148,000	$84,178,000	$57,825,000
		worst	$122,207,000	$125,262,000	$128,562,000	$131,739,000	$94,666,700
Crude	20th	*median*	$29,549,000	$30,288,000	$31,086,000	$31,854,000	$24,119,300
		worst	$36,029,000	$36,930,000	$37,903,000	$38,839,000	$29,279,400
	50th	*median*	$65,498,000	$67,135,000	$68,904,000	$70,607,000	$49,781,400
		worst	$83,698,000	$85,790,000	$88,050,000	$90,226,000	$65,079,800
	95th	*median*	$182,144,000	$186,698,000	$191,615,000	$196,351,000	$127,925,200
		worst	$230,184,000	$235,939,000	$242,154,000	$248,138,000	$168,305,800

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table 20

Total Estimated Response Costs For Oil Spills in San Francisco Bay Based on Most Probable Response Methodology[1] 2006 - 2010							
Scenario			**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**Shoreline Impact**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$12,152,050	$12,382,100	$11,762,600	$11,919,000	$12,080,580
		worst	$13,783,400	$14,007,700	$12,489,600	$12,559,700	$12,649,440
	50th	***median***	$17,329,500	$17,531,400	$15,084,800	$15,020,600	$14,908,400
		worst	$12,797,000	$13,007,200	$12,634,800	$12,784,800	$12,903,500
	95th	***median***	$24,622,200	$24,864,000	$21,012,000	$20,820,600	$20,556,100
		worst	$28,516,700	$28,753,750	$23,287,000	$22,921,800	$22,469,850
Gasoline	**20th**	***median***	$10,566,700	$10,807,300	$11,045,900	$11,291,300	$11,525,510
		worst	$10,555,800	$10,796,700	$11,041,500	$11,286,650	$11,522,370
	50th	***median***	$11,364,500	$11,595,600	$11,787,200	$12,015,200	$12,219,100
		worst	$11,338,250	$11,569,400	$11,772,800	$12,002,100	$12,207,700
	95th	***median***	$13,802,900	$14,077,750	$14,209,500	$14,470,400	$14,700,550
		worst	$15,128,400	$15,401,750	$14,983,500	$15,185,400	$15,352,600
Heavy Fuel Oil	**20th**	***median***	$9,406,250	$9,435,600	$8,245,700	$8,146,750	$8,084,510
		worst	$11,238,200	$11,270,500	$9,259,600	$9,090,250	$8,970,690
	50th	***median***	$27,121,750	$26,994,400	$20,180,000	$19,330,800	$18,380,300
		worst	$40,026,000	$39,936,800	$28,272,800	$26,979,800	$25,539,700
	95th	***median***	$57,198,750	$56,615,000	$40,113,600	$37,791,600	$35,235,100
		worst	$94,097,500	$93,623,000	$63,254,200	$59,662,900	$55,706,000
Crude	**20th**	***median***	$24,103,250	$24,117,800	$20,972,400	$20,621,500	$20,189,800
		worst	$29,247,000	$29,250,800	$23,753,400	$23,159,250	$22,464,900
	50th	***median***	$47,169,600	$46,470,000	$37,223,000	$35,426,000	$33,429,000
		worst	$62,029,400	$61,312,250	$45,900,750	$43,445,200	$40,732,700
	95th	***median***	$118,598,800	$115,387,250	$87,980,250	$81,501,600	$74,442,550
		worst	$157,823,100	$154,563,750	$110,885,750	$102,669,800	$93,719,650

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

The total response costs shown in Tables 19 and 20 are presented on a per-gallon basis in Tables 21 and 22.

Table 21

Total Estimated Response Costs (per gallon) For Oil Spills in San Francisco Bay Based on Most Probable Response Methodologies[1] 2001 - 2005							
Scenario			**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**Shoreline Impact**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	***median***	$244	$250	$257	$263	$239
		worst	$288	$295	$303	$310	$272
	50th	***median***	$70	$71	$73	$75	$64
		worst	$48	$50	$51	$52	$47
	95th	***median***	$22	$22	$23	$23	$20
		worst	$25	$26	$27	$27	$23
Gasoline	**20th**	***median***	$200	$205	$211	$216	$207
		worst	$200	$205	$211	$216	$207
	50th	***median***	$41	$42	$43	$44	$41
		worst	$41	$42	$43	$44	$41
	95th	***median***	$11	$11	$11	$12	$11
		worst	$12	$12	$13	$13	$12
Heavy Fuel Oil	**20th**	***median***	$465	$476	$489	$501	$376
		worst	$557	$571	$586	$600	$449
	50th	***median***	$351	$360	$369	$378	$273
		worst	$505	$518	$532	$545	$402
	95th	***median***	$190	$195	$200	$205	$141
		worst	$298	$306	$314	$321	$231
Crude	**20th**	***median***	$295	$303	$311	$319	$241
		worst	$360	$369	$379	$388	$293
	50th	***median***	$109	$112	$115	$118	$83
		worst	$139	$143	$147	$150	$108
	95th	***median***	$61	$62	$64	$65	$43
		worst	$77	$79	$81	$83	$56

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table 22

Total Estimated Response Costs (per gallon) For Oil Spills in San Francisco Bay Based on Most Probable Response Methodology[1] 2006 - 2010							
Scenario			**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**Shoreline Impact**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$243	$248	$235	$238	$242
		worst	$276	$280	$250	$251	$253
	50th	***median***	$64	$65	$56	$56	$55
		worst	$47	$48	$47	$47	$48
	95th	***median***	$20	$20	$17	$17	$16
		worst	$23	$23	$19	$18	$18
Gasoline	**20th**	***median***	$211	$216	$221	$226	$231
		worst	$211	$216	$221	$226	$230
	50th	***median***	$42	$43	$44	$45	$45
		worst	$42	$43	$44	$44	$45
	95th	***median***	$11	$11	$11	$12	$12
		worst	$12	$12	$12	$12	$12
Heavy Fuel Oil	**20th**	***median***	$376	$377	$330	$326	$323
		worst	$450	$451	$370	$364	$359
	50th	***median***	$271	$270	$202	$193	$184
		worst	$400	$399	$283	$270	$255
	95th	***median***	$140	$138	$98	$92	$86
		worst	$230	$228	$154	$146	$136
Crude	**20th**	***median***	$241	$241	$210	$206	$202
		worst	$292	$293	$238	$232	$225
	50th	***median***	$79	$77	$62	$59	$56
		worst	$103	$102	$77	$72	$68
	95th	***median***	$40	$38	$29	$27	$25
		worst	$53	$52	$37	$34	$31

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

9.0 Issues Regarding Extraordinary Oil Spill Response Costs

All estimations presented in sections 3.0 to 8.0 are based on the assumption of *reasonable* and *typical* costs expected for spill responses based on current regional resources and capabilities and contingency planning as described in the relevant current Area Contingency Plan (US Coast Guard 2001). The costs have been adjusted for the amount and type of oil spilled and surface oil spreading and shoreline oiling as modeled by SIMAP.

As noted earlier in Section 1.0, historical case studies have shown that there are exceptional cases with extremely high costs attributable to a variety of factors and complications. *Caution should be exercised when examining and comparing costs between historical spill cases as the reported or rumored costs (even for allegedly "well-known" cases) do not always accurately reflect true response costs. They sometimes include non-response related costs (e.g., wildlife rehabilitation or natural resource damage assessment studies) or omit costs that would normally be included as response* *costs (e.g., source control and salvage, spill management, oily waste disposal, or equipment decontamination). There are also differences between reported costs incurred by response organizations under contract with response organizations and costs incurred by government-directed responders.*

The most *common* factors impacting response costs for a particular spill scenario (location, type of oil, amount of oil) – degree of shoreline oiling – have already been dealt with as an integral part of the modeling conducted. The simulation of 100 possible outcomes of surface oiling and shoreline impact based on variations in tidal conditions, winds, and currents have shown the variety of shoreline oiling conditions that can occur and the manner in which those varied impacts can influence response costs.

Another common factor impacting response costs – effectiveness of on-water mechanical recovery – has also been factored into the analyses by erring on the side of an assumption of negligible recovery with no reduction of shoreline oiling from on-water recovery. This would tend to maximize overall response costs by assuming that the Area Contingency Plan (US Coast Guard 2001) is properly carried out with maximum costs incurred by mobilization and possible deployment of equipment and personnel (which net the same costs whether actually deployed or maintained on standby). Costs for processing of oily waste are estimated based on historically moderate to high estimates of oil recovery (15% with emulsification of oil as described in Section 3.0).

Some of the less typical complicating factors have, however, not been captured by the analyses conducted. Various types of errors in judgment or management, "overkill" actions, inappropriate expenditures, and public relations strategies that can lead to excessive costs are notably difficult to predict and factor into cost estimations of responsible party liability. An analogy would be a health insurer being prepared for "reasonable" charges for a particular surgical procedure but not necessarily expecting to pay for unusual complications that might occur due to chance occurrences or negligent actions on the part of the surgical team.

The possible relevance of response cost-increasing complications to the potential spill scenarios in question for San Francisco Bay is discussed here.

- ***Excessive Equipment/Personnel Mobilization***

Costs for mechanical recovery operations can become escalated when unexpected redundancies of equipment and/or personnel are mobilized due to miscommunications or mismanagement. This has occurred in some historical cases. In some cases, there has been a miscommunication or error in judgment as to the magnitude of the spill, bringing in an overabundance of equipment or personnel.

In some past cases (e.g., PEPCO pipeline spill), arguably unnecessary or inappropriate expensive equipment (e.g., large oil recovery vessels which cost $35,000 per day but only operate in deeper water) has been brought on scene to give the appearance of "no costs spared" or "doing everything possible" as part of a public relations posture by the responsible party. In some historical cases (e.g., M/V *Kure* spill), excessive equipment mobilization has occurred when there is considerable public concern about *potential* spill impacts on highly sensitive areas (e.g., bird sanctuaries) coupled with an initial overestimation of potential spill volume.

These actions can dramatically increase costs for mechanical recovery-based operations. In the only closely studied example of this phenomenon (a study of the PEPCO spill conducted by Environmental Research Consulting under subcontract to Research Planning Inc. for the client US Maritime Administration), costs were increased an estimated 40% from what would be considered "reasonable" expenses for equipment and personnel.

In cases of very small spills that have the potential for becoming much larger and having great impact in the opinion of on-scene coordinators and officials, there can also be excessive costs incurred, particularly when viewed on a *per-gallon* basis using the *actual* spill volume (notably the M/V *Kure* spill of nearly $2,300 per gallon for a spill of only 4,500 gallons).

The potential for excessive equipment/personnel expenditures to occur in a California spill for reasons of *over-cautiousness from a protection standpoint* (or for public relations posturing) is considerable due to the highly involved and motivated public and state agencies. This already occurred during the response to the M/V *Kure* spill in Humboldt Bay, as explained earlier. This type of over-expenditure is, however, generally more likely to occur in what turns out to be a *minor* incident in terms of the actual oil spilled. It is not as likely to be a critical factor in this analysis. Even the smallest category (20th percentile) of the potential spills considered in this analysis – 25,000 gallons of heavy fuel oil – would call for mobilization of a fair amount of mechanical containment and recovery equipment (estimated to cost at minimum $500,000 for San Francisco Bay based on costs incurred for mobilization of equipment for a spill exercise in which no equipment was actually used). This minimum "startup cost" for equipment mobilization is already assumed in these analyses. (The "startup cost" is why smaller spills are more expensive on a per-gallon basis than larger spills.)

The potential for redundant equipment and personnel is more likely for smaller or moderate-sized spills than for very large spills in which regional resource capabilities are already likely to be used to maximum or near maximum capacity. Larger responses require extensive communication between response organizations and cooperatives, creating less likelihood of doubling of efforts. Another consideration is that the type of miscommunication and confusion that increased costs in the response to the PEPCO pipeline spill occurred when the facility operators decided to take charge of the response operations rather than defer to a more experienced outside spill management team. The larger shipping companies whose deep-draft ships transit San Francisco Bay are more likely to have an *established* relationship with an experienced Qualified Individual and associated spill management team as stipulated by their vessel response plan and less likely to have the personnel (and equipment) available on board the vessel to attempt a response themselves.

While excessive expenditure on mechanical recovery equipment and personnel due to miscommunication, mismanagement, or other reasons is unlikely to occur in the San Francisco Bay scenarios in question, an additional 40% of cost can be factored in to estimate a maximum cost for mechanical recovery operations (as shown in Table 23).

The worst case for dispersant applications is that the dispersant is completely ineffective or conditions are inappropriate or less than optimal for application and all of the oil impacts the shoreline. The costs would then be comparable to the costs for the dispersant *application* plus the maximum costs for mechanical recovery operations (40% above reasonable costs previously calculated) including *total* shoreline impact rather than the reduced impact assumed with dispersant application. This assumes that the dispersant applications were carried out but were completely ineffective and response officials called out an overabundance of mechanical recovery equipment due to miscommunication, poor judgment, and/or mismanagement. These results are also shown in Table 23.

- ***Natural Disasters and Bad Weather Conditions***

An unpredictable factor that can interfere with mechanical response operations and possibly increase costs compared to an "ideal" response is bad weather (storms, blizzards, hurricanes, etc.) or other natural disaster (e.g., earthquake) that postpones or negates early response measures (particularly, protective booming) and allows oil to escape booming causing more shoreline impact.

While the possibility for storms and earthquakes certainly exists in the San Francisco Bay area, this does not need to be factored into the current analysis since the worst that can happen under these conditions is that all of the oil impacts the shoreline. This has already been assumed in the trajectory modeling by assuming that none of the oil is removed by mechanical recovery and that oil goes over or under protective booms when exceeding threshold wave heights and current conditions. In fact, stormy weather tends to break down the oil further and often makes shoreline cleanup less necessary on coastal areas exposed to high-energy waves.

- ***Inappropriate Expenditures***

Occasionally, there are anecdotal reports of "inappropriate" expenditures by response organizations and spill managements teams allegedly including unnecessary "luxury" rental automobiles and excessive dining and entertainment expenses. Evidence of these types of expenditures is often brought out in litigation between the responsible party and its spill management team and/or response organizations. There is always a possibility that this type of expense can be incurred though it would seem to be less likely for a spill response that is managed by a reputable response organization and spill management team.

When these expenses are incurred, however, they are usually rejected by the responsible party's insurer and settled during litigation. These types of over-expenditures need not be factored into the current analysis.

- ***Excessive Costs For Wildlife Rehabilitation***

Reports of *Exxon Valdez* spill "response" costs – estimated to be over $3.7 billion (in 2001 dollars) included expenditures that may not ordinarily be considered true *response* costs – or oil *removal* costs. An illustrative example is the costs incurred by Exxon Shipping Company for wildlife rehabilitation. A reported $116,000 (in 2001 dollars) was spent on *each* oiled sea otter. These extraordinary costs were incurred for designing, building, and staffing rehabilitation centers, training volunteers and paid staff, and flying in market-priced fresh abalone and other fresh shellfish to feed to the otters.

Over-expenditure of this magnitude in the San Francisco Bay spills is unlikely since because of the diligence of California agencies and environmental groups there is an excellent pre-existing network of wildlife rehabilitation centers. Additionally, the International Bird Rescue Research Center is located in Berkeley, California. Expenses for building rehabilitation centers will not be necessary and costs for training staff and volunteers will not likely become excessive. These costs will more likely also be contained within the category of natural resource damage assessment and restoration costs.

Table 23

Estimated Maximum Total Response Costs For Oil Spills In San Francisco Bay (including shoreline response)				
Scenario		**Spill Outcome**[1]	**Primary On-Water Response Strategy**	
Oil Type	**Percentile Gallons**		**Mechanical**[2]	**Dispersants**[3]
Diesel	**20th (50,000)**	Median	$17,087,700	$17,172,700
		Worst	$20,139,700	$20,224,700
	50th (270,000)	Median	$26,303,900	$26,779,900
		Worst	$18,309,900	$18,785,900
	95th (1,250,000)	Median	$37,652,300	$40,214,300
		Worst	$44,330,300	$46,892,300
Gasoline	**20th (50,000)**	Median	$14,029,400	$14,122,400
		Worst	$14,009,800	$14,102,800
	50th (270,000)	Median	$15,461,600	$15,910,600
		Worst	$15,414,000	$15,863,000
	95th (1,250,000)	Median	$18,762,800	$20,755,800
		Worst	$21,035,000	$23,028,000
Heavy Fuel Oil	**20th (25,000)**	Median	$16,266,600	$16,336,600
		Worst	$19,486,600	$19,556,600
	50th (100,000)	Median	$49,149,800	$49,347,800
		Worst	$70,751,800	$70,949,800
	95th (410,000)	Median	$109,321,800	$109,953,800
		Worst	$171,089,800	$171,721,800
Crude	**20th (100,000)**	Median	$41,368,600	$41,532,600
		Worst	$50,440,600	$50,604,600
	50th (600,000)	Median	$91,697,200	$92,727,200
		Worst	$117,177,200	$118,207,200
	95th (3,000,000)	Median	$255,001,600	$259,874,600
		Worst	$322,257,600	$327,130,600

[1]Shoreline costs for median/worst water column-impacted runs for diesel and gasoline and median/worst shoreline cost runs for HFO and crude based on SIMAP modeling runs, with "worst" defined as 95th percentile.
[2]Assumes that excessive mechanical recovery equipment and personnel mobilized creating overall increase in expenditures as found to occur in the PEPCO Pipeline spill in Maryland.
[3]Assumes that dispersant application carried out or mobilized is completely ineffective and that a concurrent or subsequent overabundant mechanical recovery effort is mobilized as under (2).

10.0 Development of Full Cost Distributions From Percentile Case Costs

Since the initial statement of work for this study called for modeling of the *50th percentile (median) and 95th percentile ("worst") damages for each of the scenarios*, the data are presented in sections 3.0 to 8.0 of this report are presented as median and worst cases for each of the 12 scenarios. Nevertheless, there is a methodology that might be used to approximate a more continuous distribution of costs and to find the true "worst case" (99th percentile) cost for mechanical response operations:

1. Take SIMAP output for the entire range of shoreline response costs (100 runs) *all* oil types.
2. Add the applicable mechanical recovery costs, as well as applicable salvage/ source control and spill management costs, to the shoreline costs for each of the 100 runs to develop a new distribution of total costs. This would produce a distribution of costs for mechanical recovery operations for each of the 12 scenarios (as shown in Figures 123 - 134) and the ranges of costs (minimum – 1st percentile, median, and maximum – 99th percentile) shown in Table 24.

Figure 123

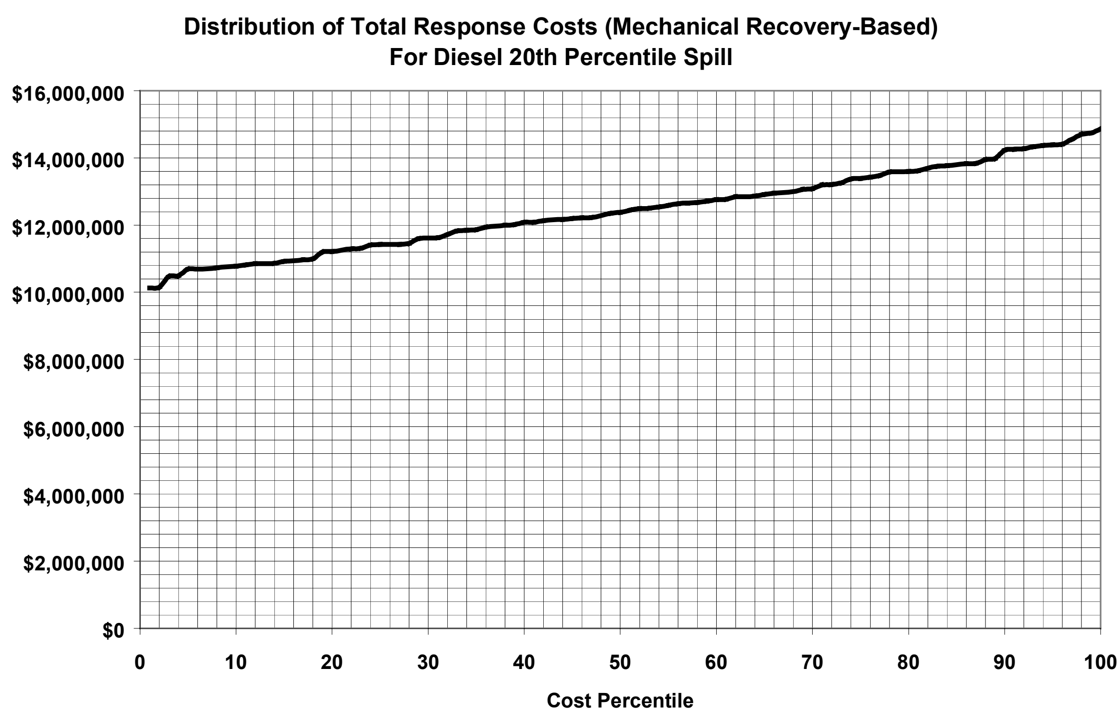


Figure 124

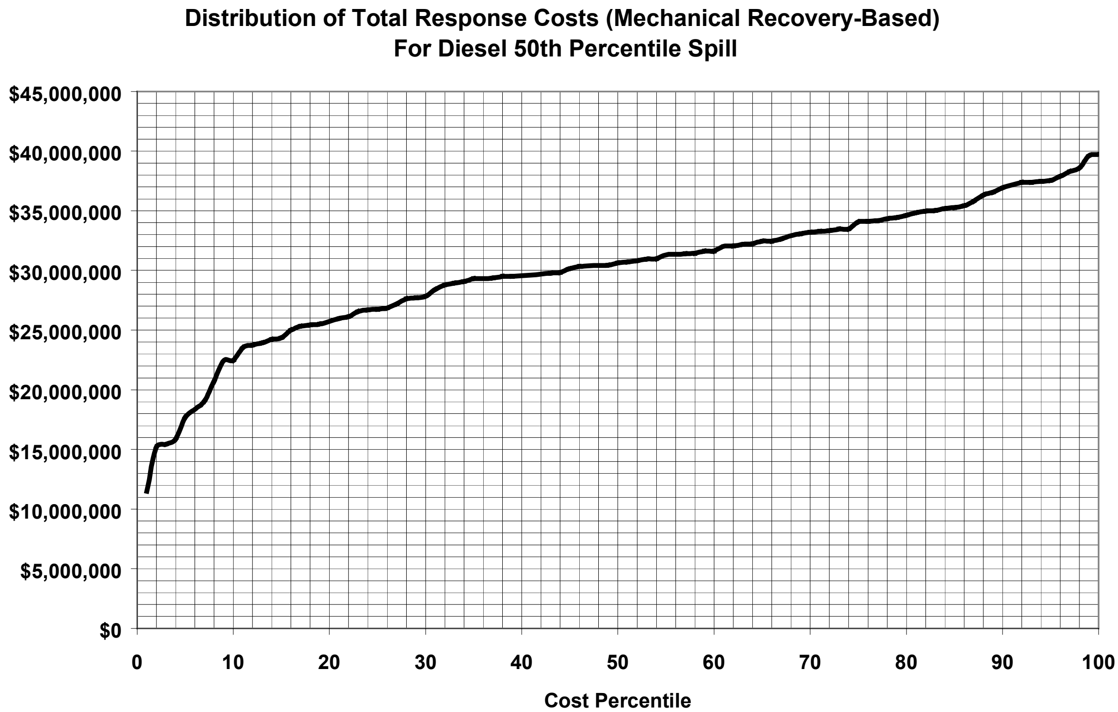


Figure 125

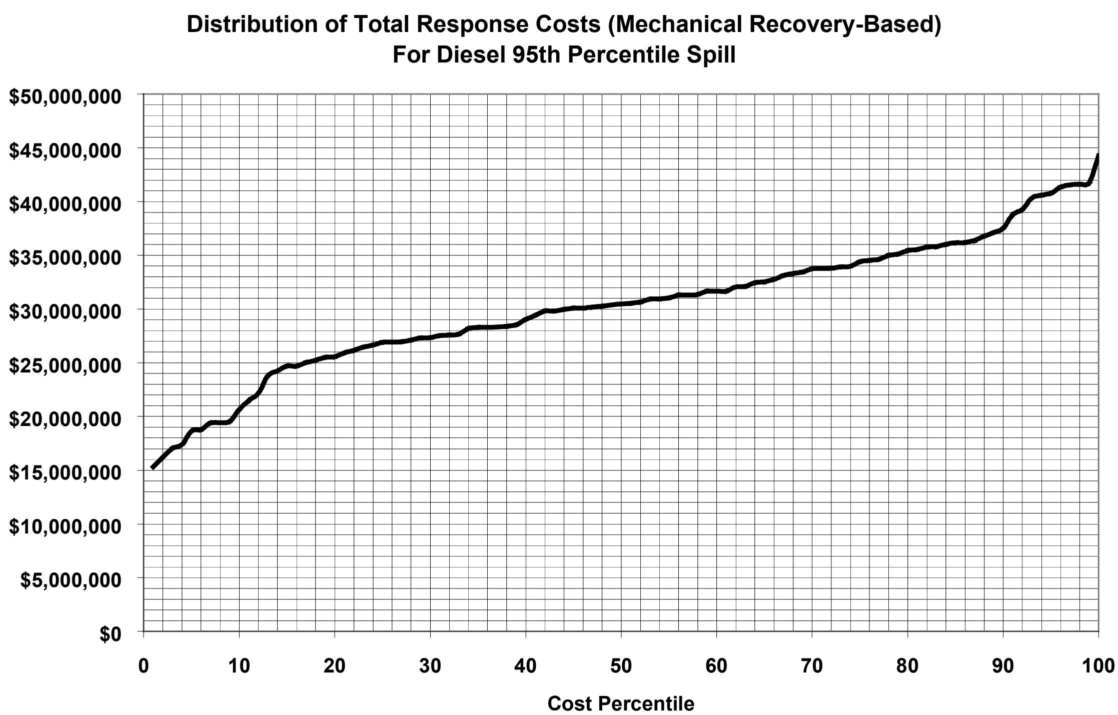


Figure 126

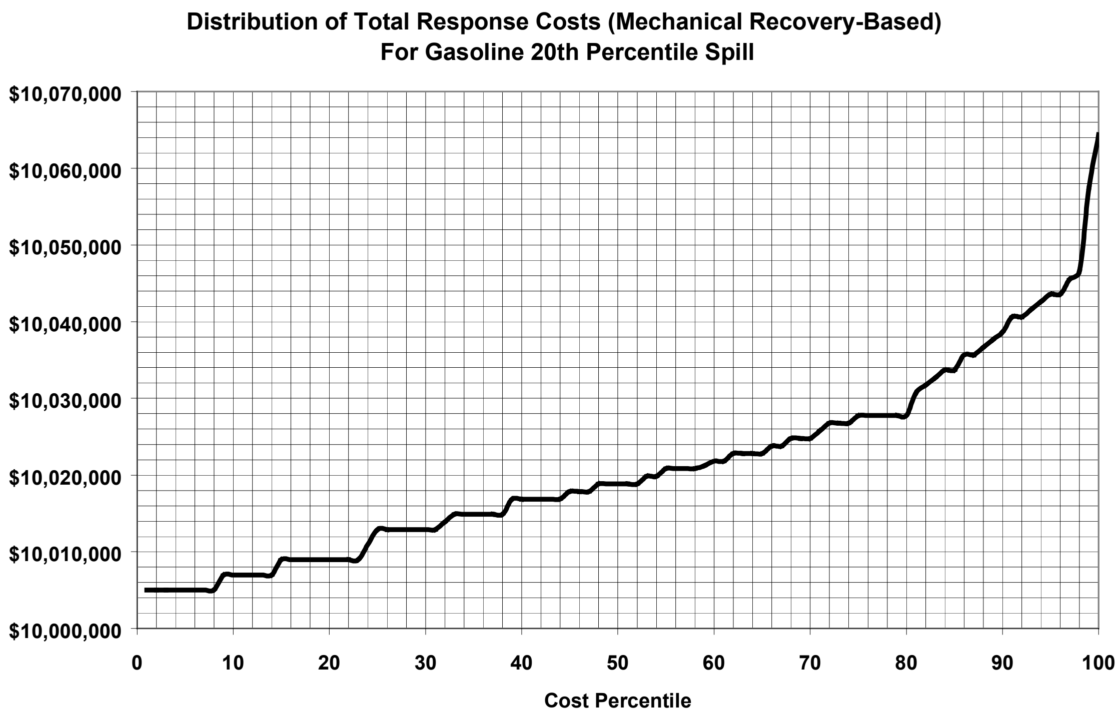


Figure 127

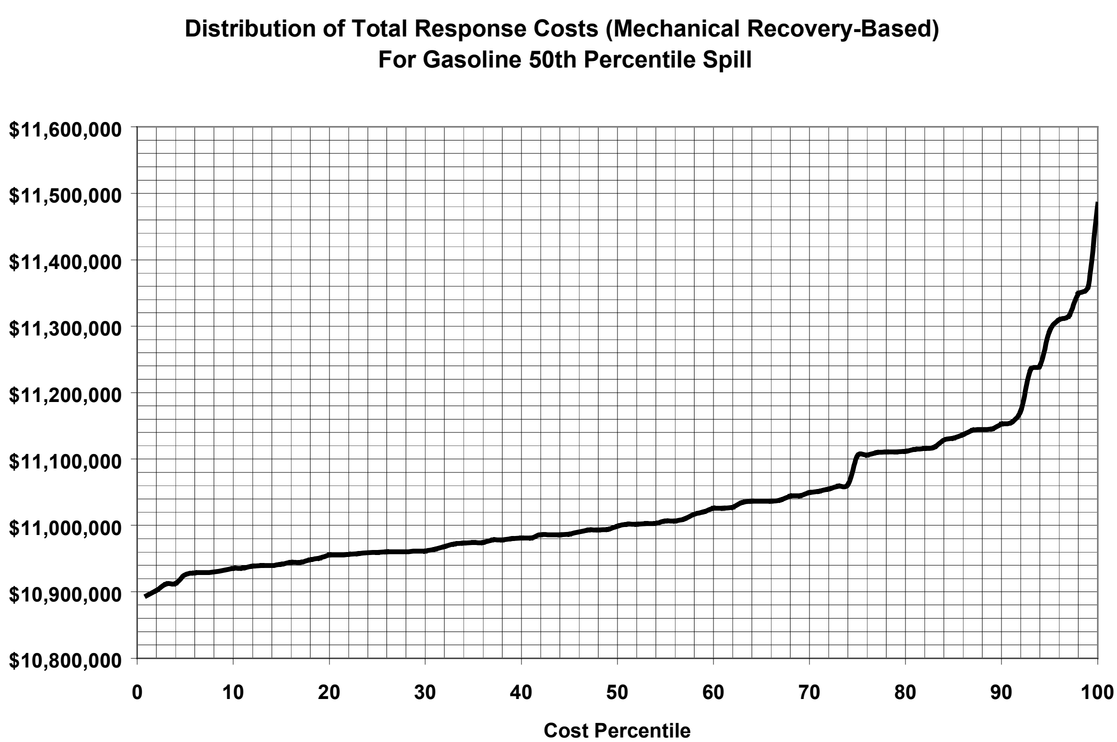


Figure 128

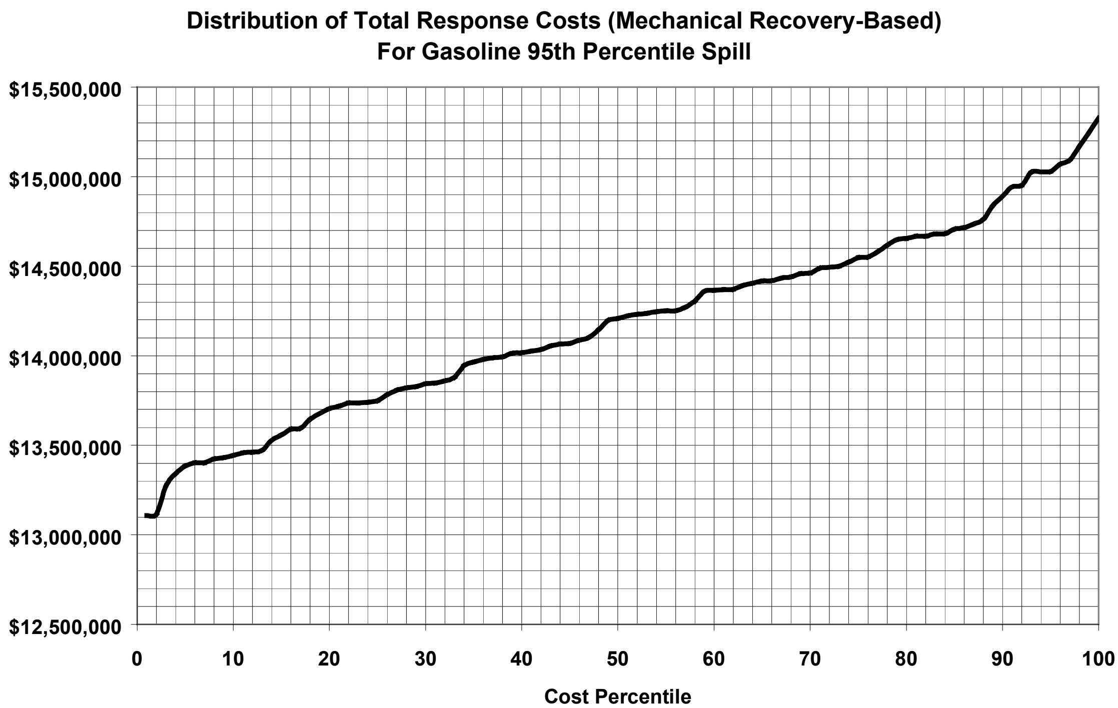


Figure 129

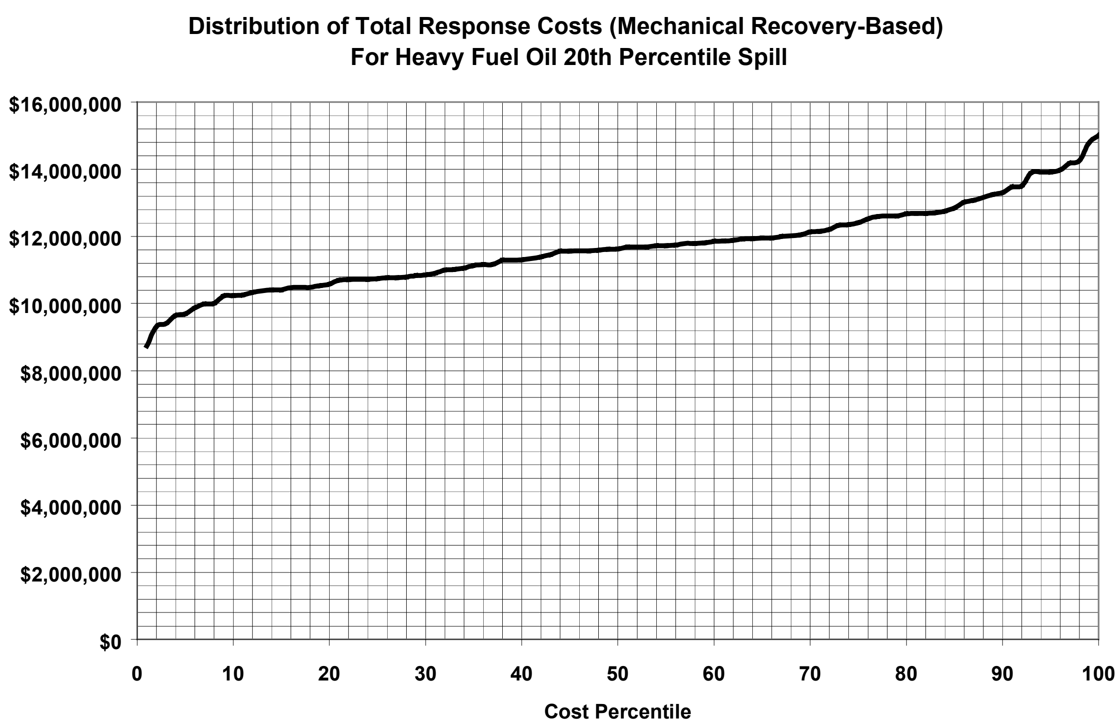


Figure 130

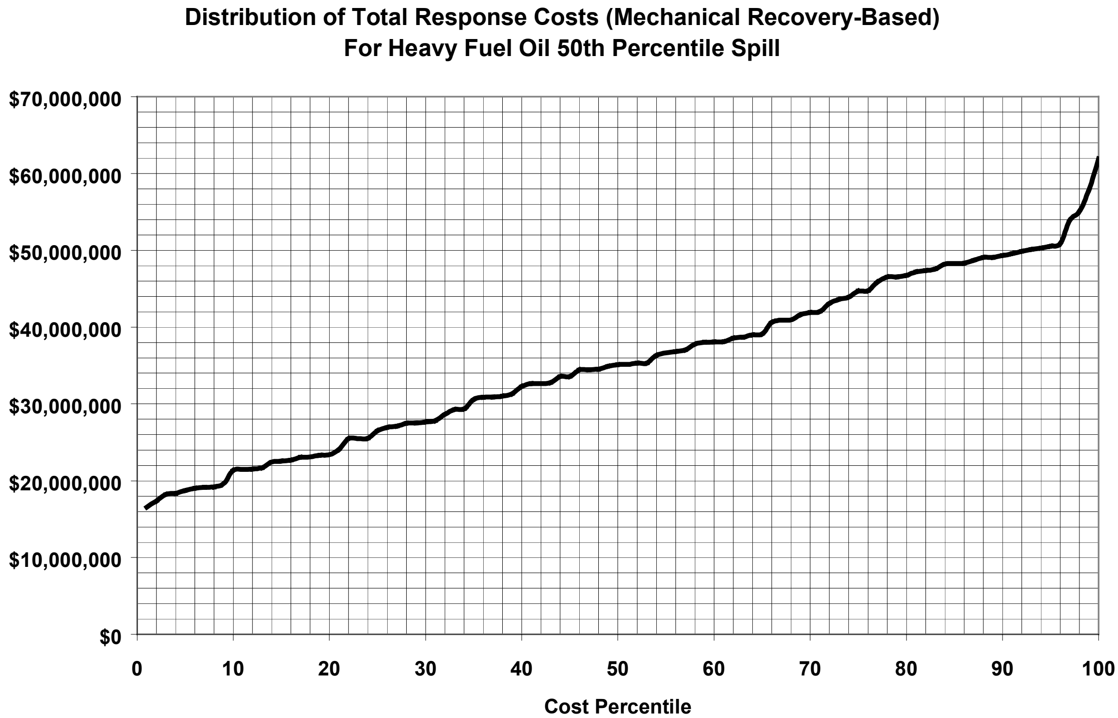


Figure 131

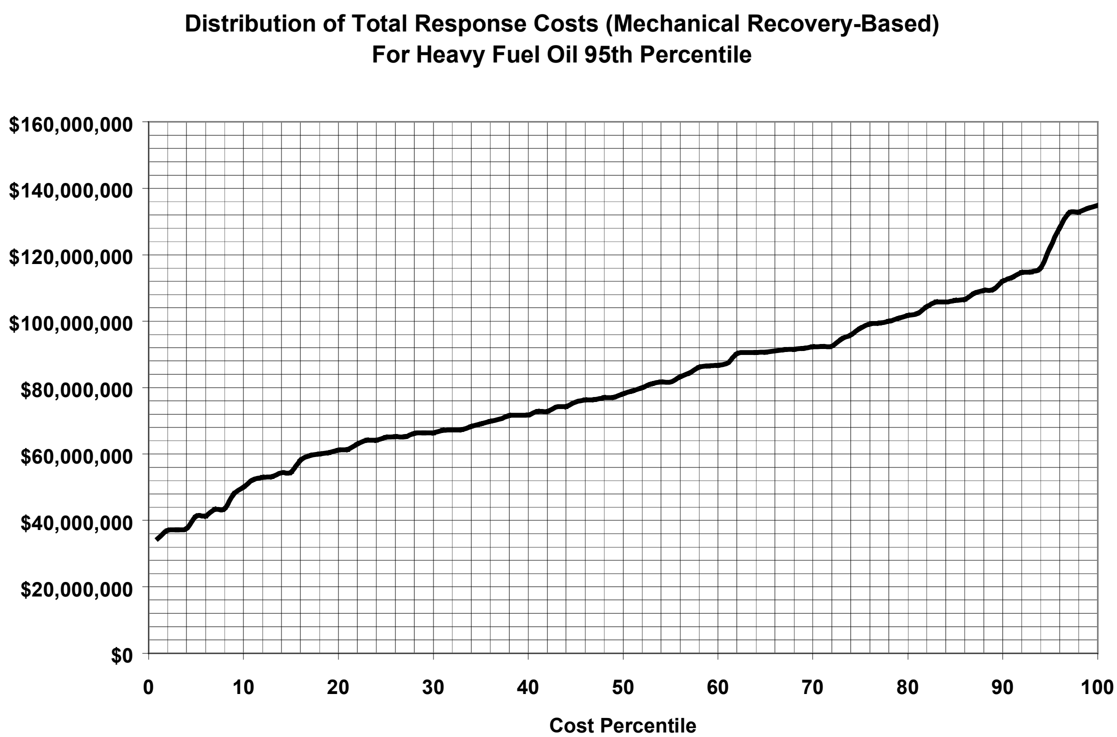


Figure 132

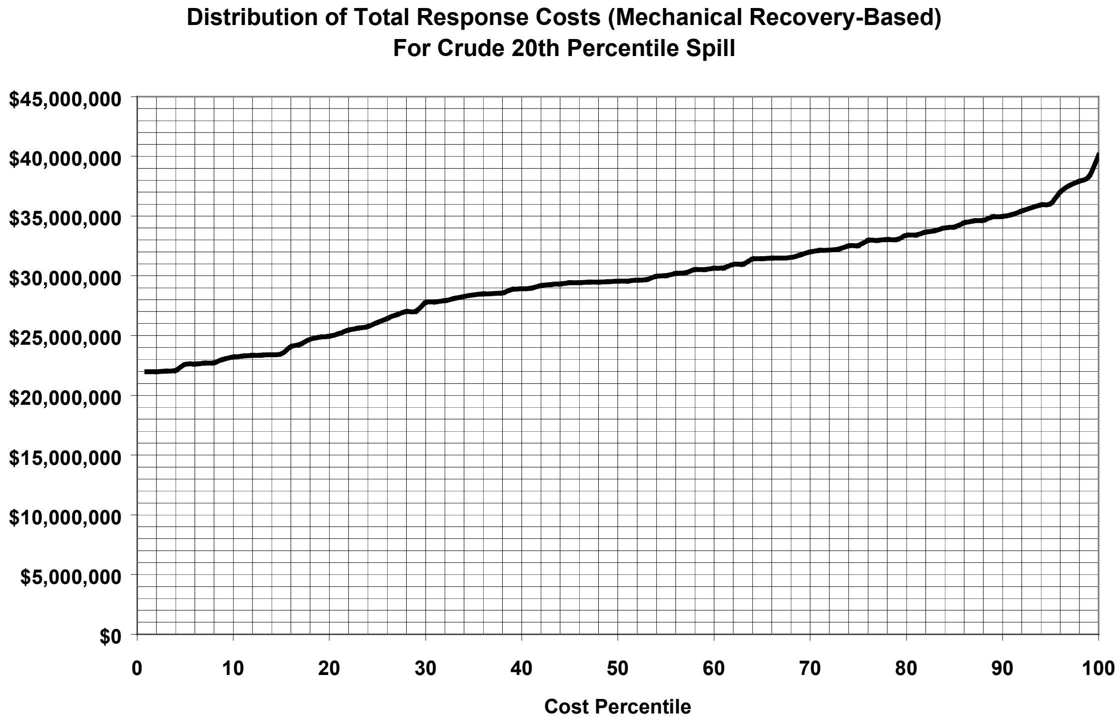


Figure 133

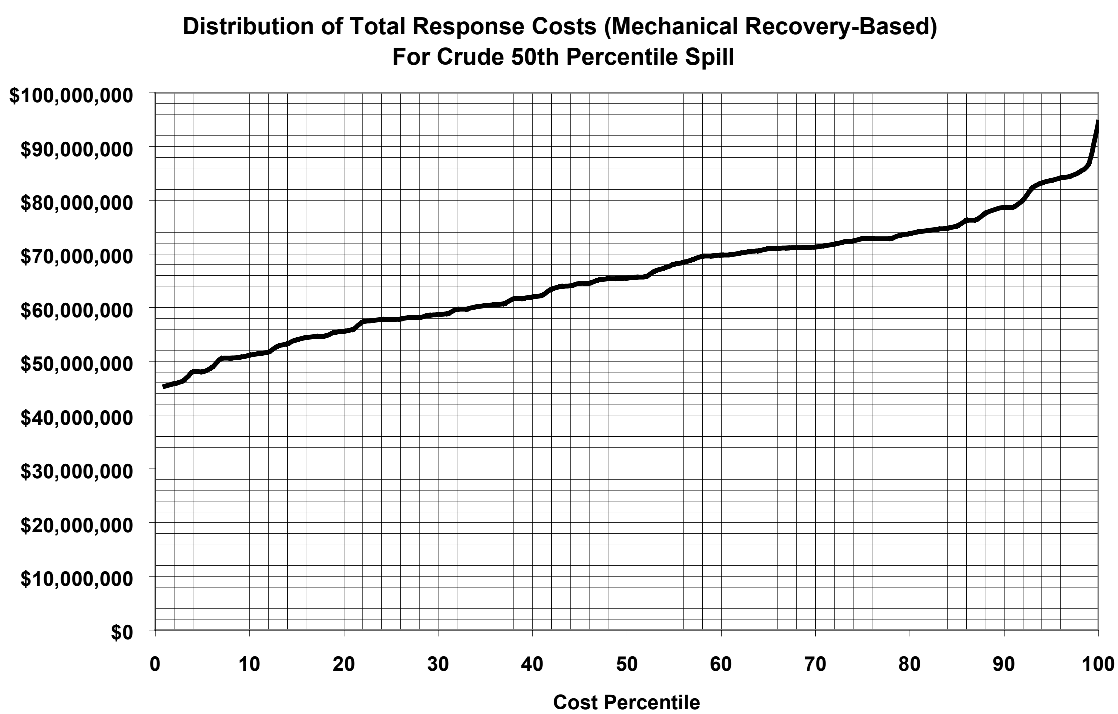
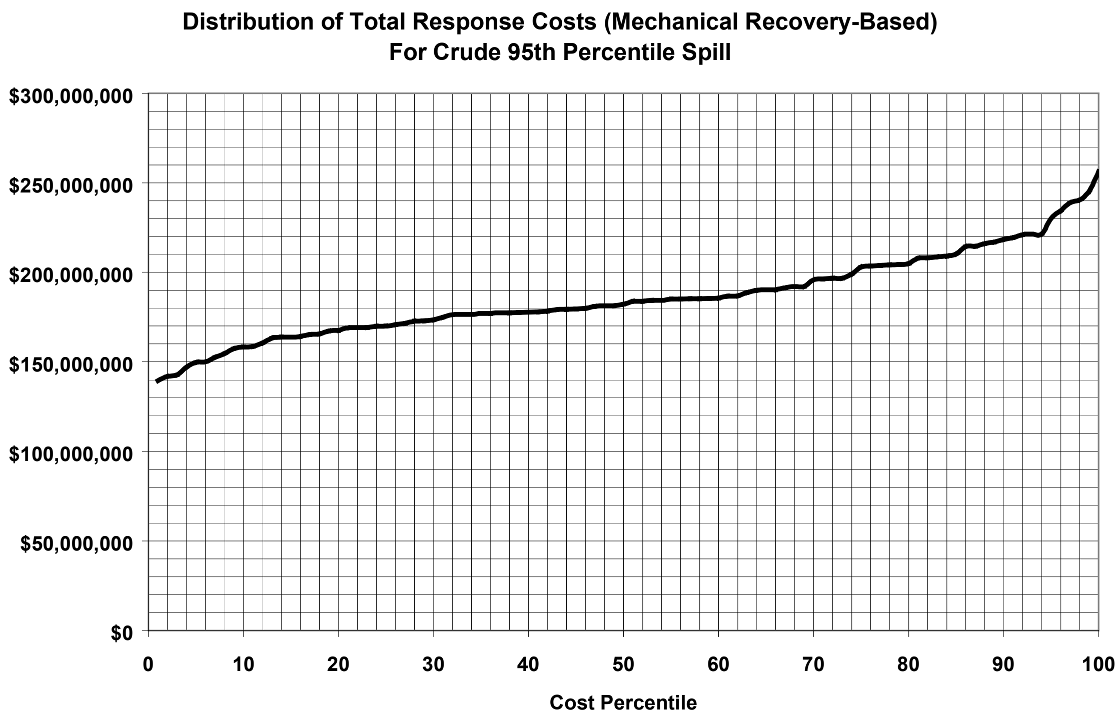


Figure 134



Distribution of Total Response Costs (Mechanical Recovery-Based)
For Crude 95th Percentile Spill
$300,000,000
$250,000,000
$200,000,000
$150,000,000
$100,000,000
$50,000,000
$0
0
10
20
30
40
50
60
70
80
90
100
Cost Percentile

Table 24

Estimated Total Mechanical Response Costs For Oil Spills In San Francisco Bay (including shoreline response, salvage, disposal, spill management)				
Oil	**Percentile (Gallons)**	**Minimum 1st percentile**	**Median 50th percentile**	**Maximum 99th percentile**
Diesel	**20th (50,000)**	\$10,125,596	\$12,376,836	\$14,866,428
	50th (270,000)	\$11,485,592	\$30,628,288	\$39,740,902
	95th (1,250,000)	\$15,324,533	\$30,466,580	\$44,266,728
Gasoline	**20th (50,000)**	\$10,005,000	\$10,018,850	\$10,064,358
	50th (270,000)	\$10,894,036	\$10,998,868	\$11,483,649
	95th (1,250,000)	\$13,107,021	\$14,208,135	\$15,327,081
Heavy Fuel Oil	**20th (25,000)**	\$8,737,341	\$11,623,651	\$15,009,354
	50th (100,000)	\$16,568,868	\$35,110,556	\$61,916,104
	95th (410,000)	\$34,609,334	\$78,090,804	\$134,852,320
Crude	**20th (100,000)**	\$21,969,760	\$29,544,132	\$40,100,880
	50th (600,000)	\$45,366,627	\$65,497,384	\$94,502,080
	95th (3,000,000)	\$139,511,656	\$182,145,156	\$256,124,736

This methodology can also be applied to dispersant costs by assuming that the distribution of shoreline impact as modeled by SIMAP are reduced by the effectiveness level of the dispersant for each oil type (35% for HFO and 40% for other oils for the lower effectiveness; and 70% reduction for HFO and 80% for other oils for the higher effectiveness). These results are then added to the costs of dispersant application, salvage/source control, and spill management costs to produce a distribution for each scenario. The results are shown in Figures 135 - 146 and Tables 25 - 26.

Figure 135

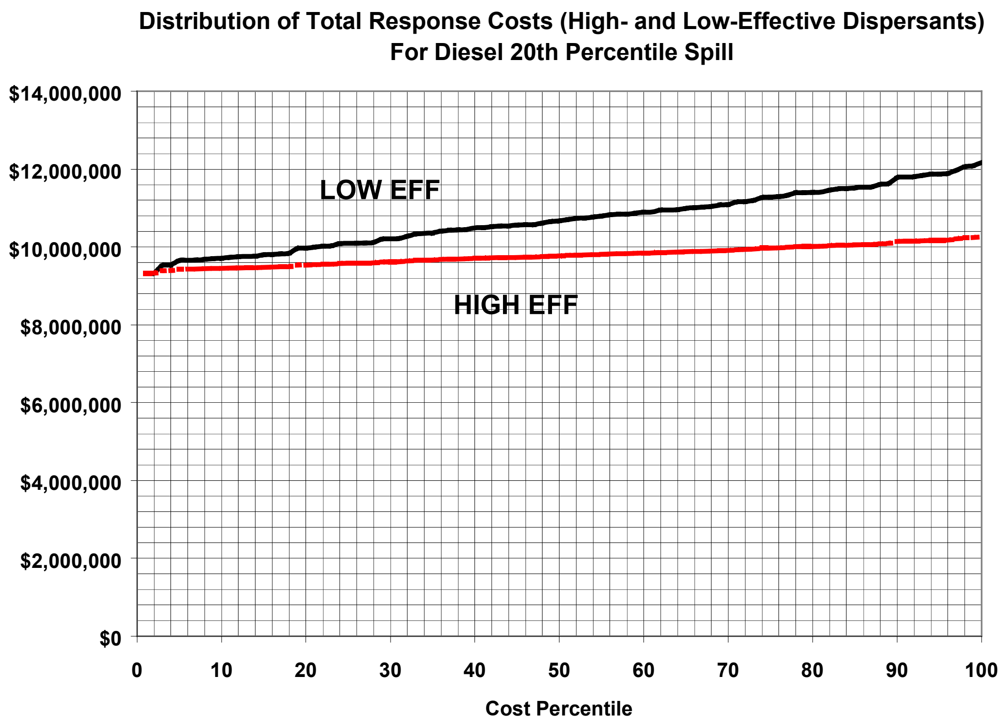


Figure 136

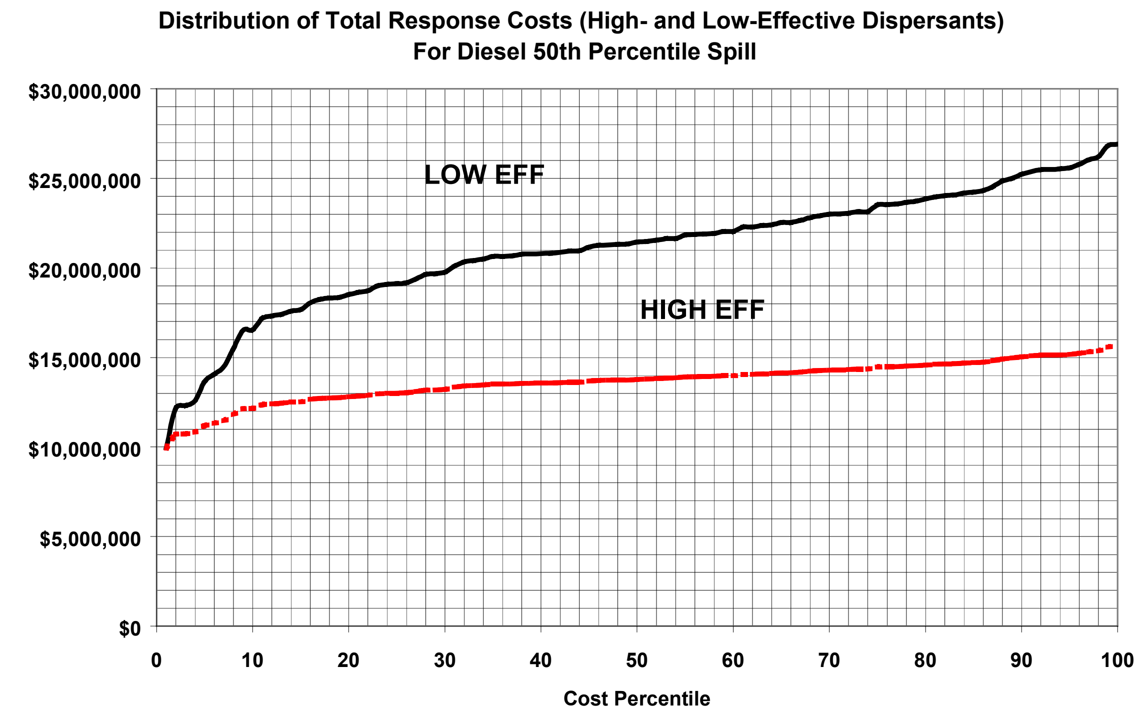


Figure 137

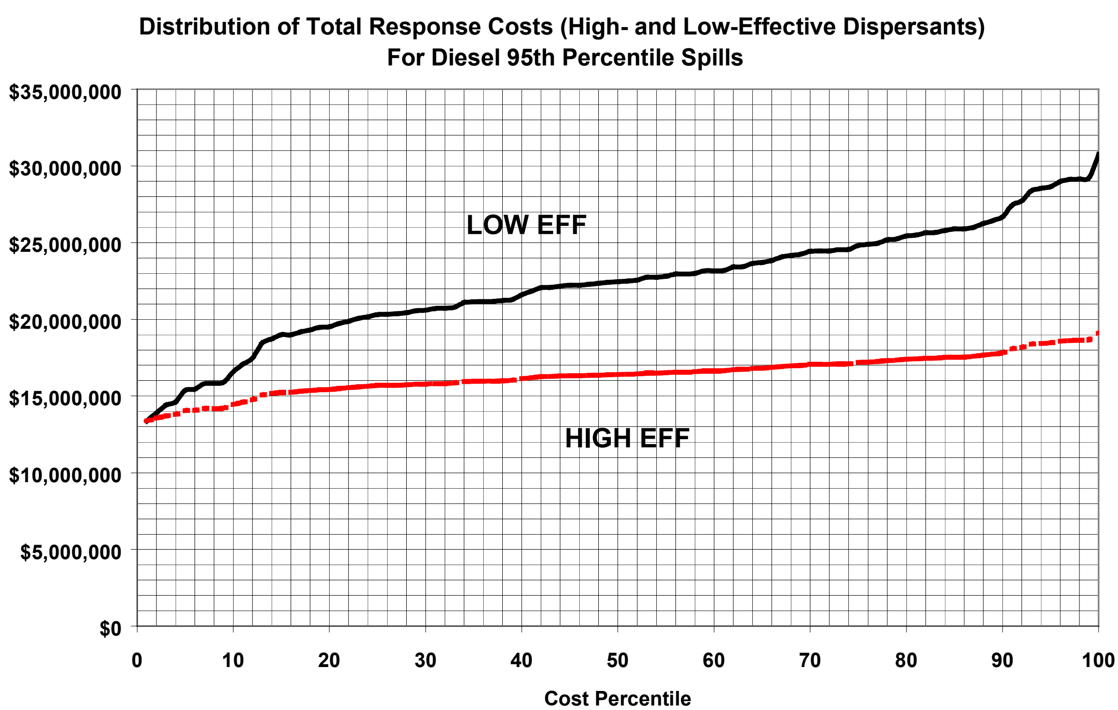


Figure 138

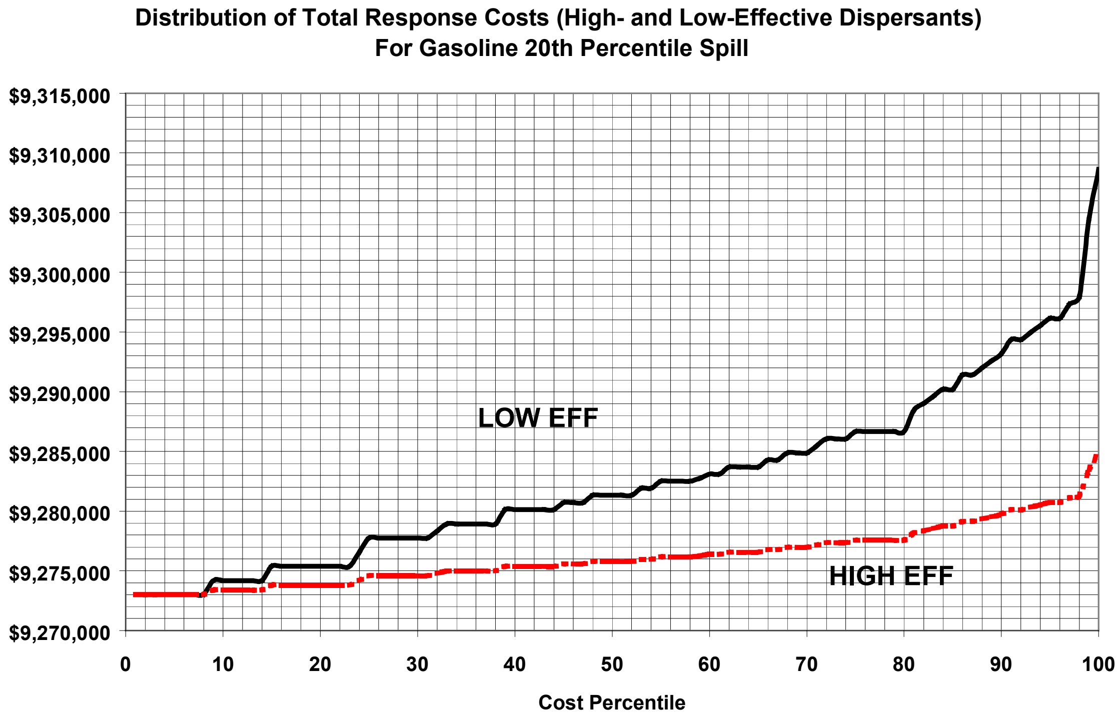


Figure 139

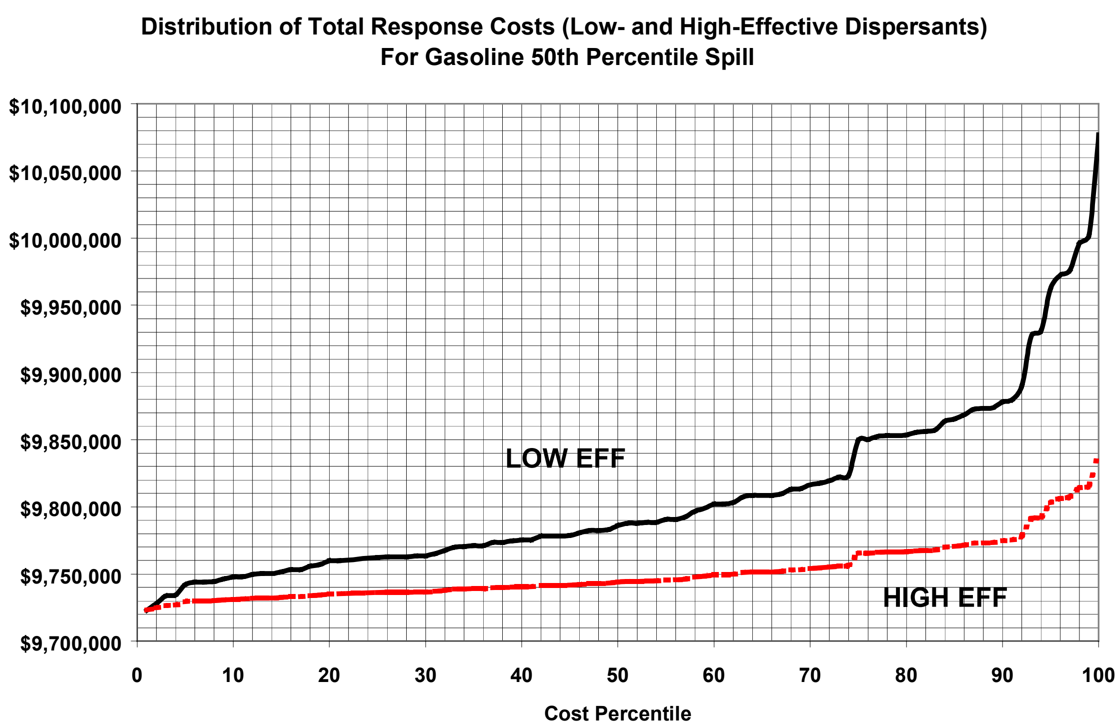


Figure 140

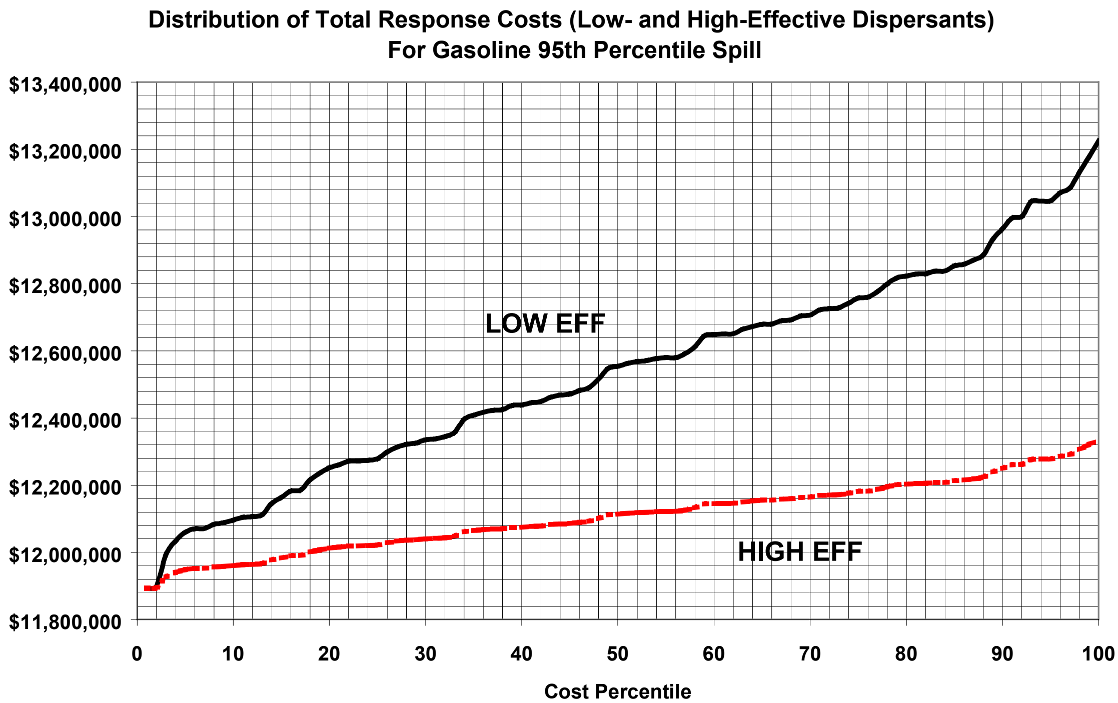


Figure 141

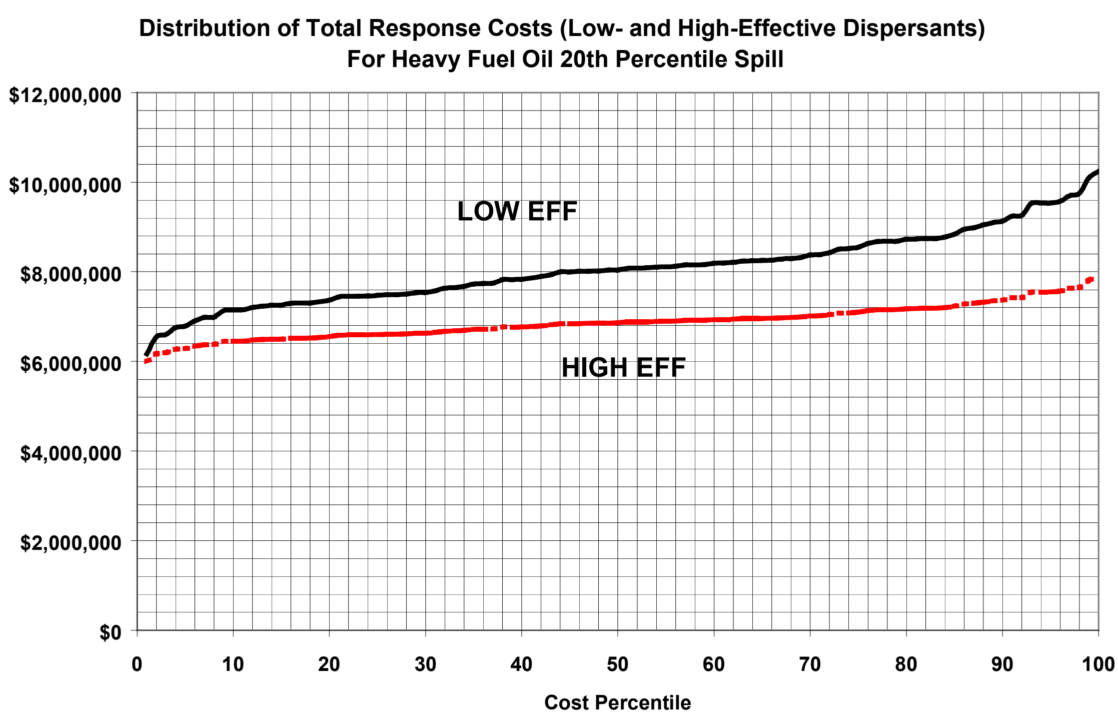


Figure 142

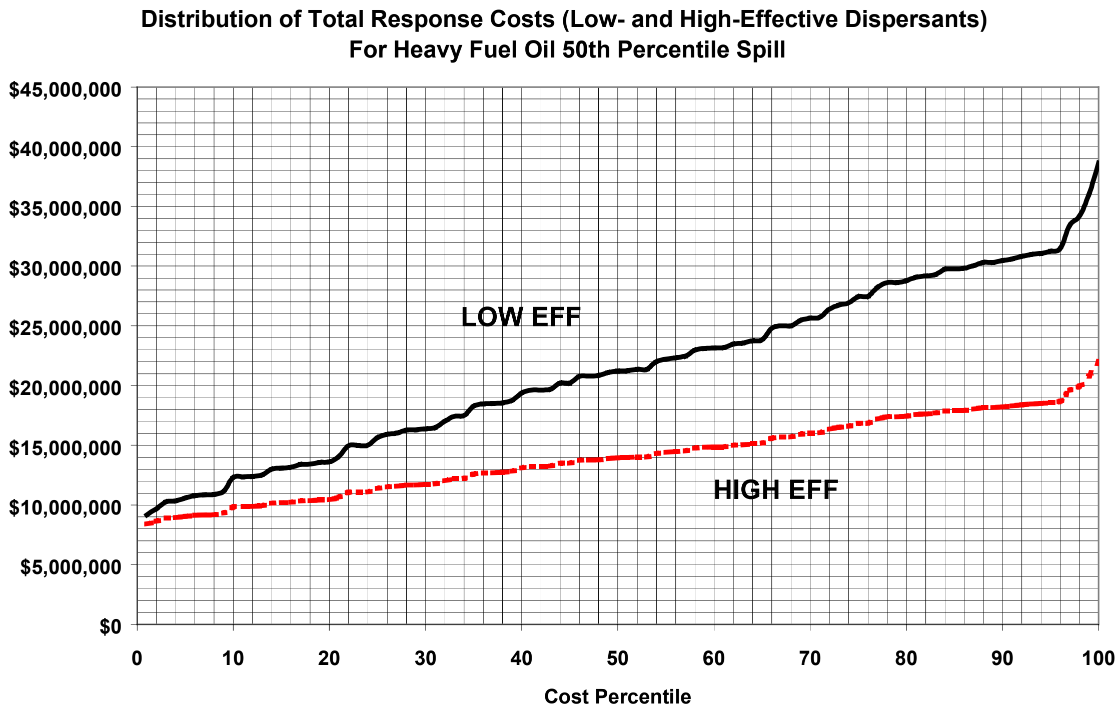


Figure 143

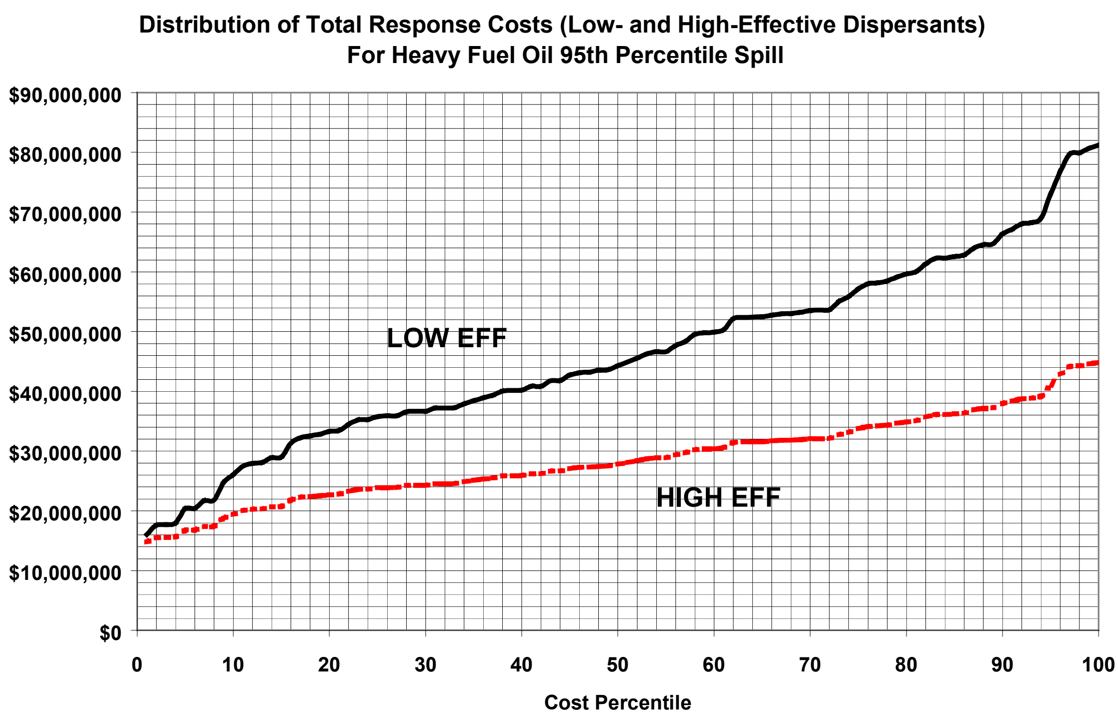


Figure 144

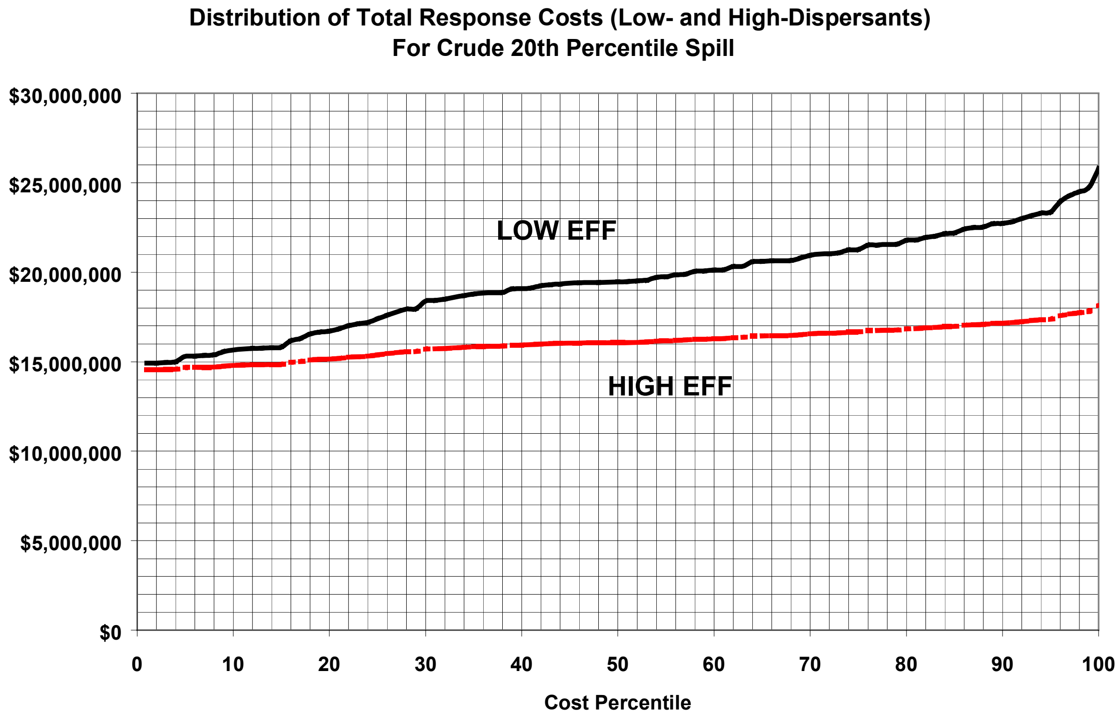

Distribution of Total Response Costs (Low- and High-Dispersants)
For Crude 20th Percentile Spill
$30,000,000
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$0
0
10
20
30
40
50
60
70
80
90
100
Cost Percentile
LOW EFF
HIGH EFF

Figure 145

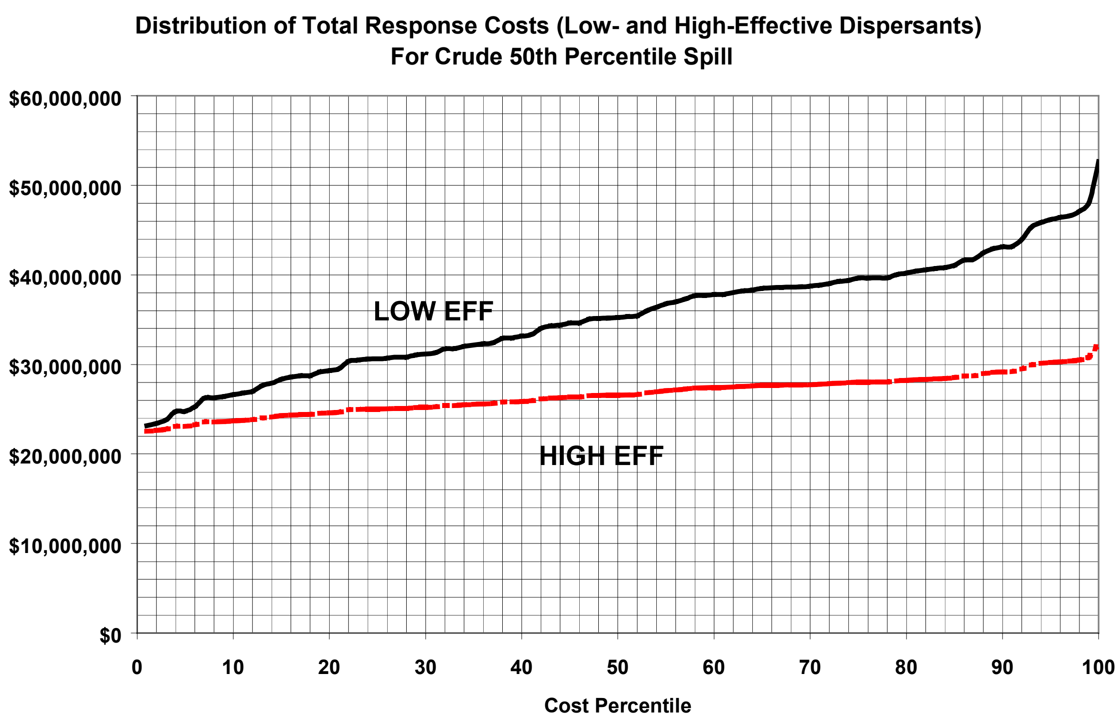

Distribution of Total Response Costs (Low- and High-Effective Dispersants)
For Crude 50th Percentile Spill
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
0
10
20
30
40
50
60
70
80
90
100
Cost Percentile
LOW EFF
HIGH EFF

Figure 146

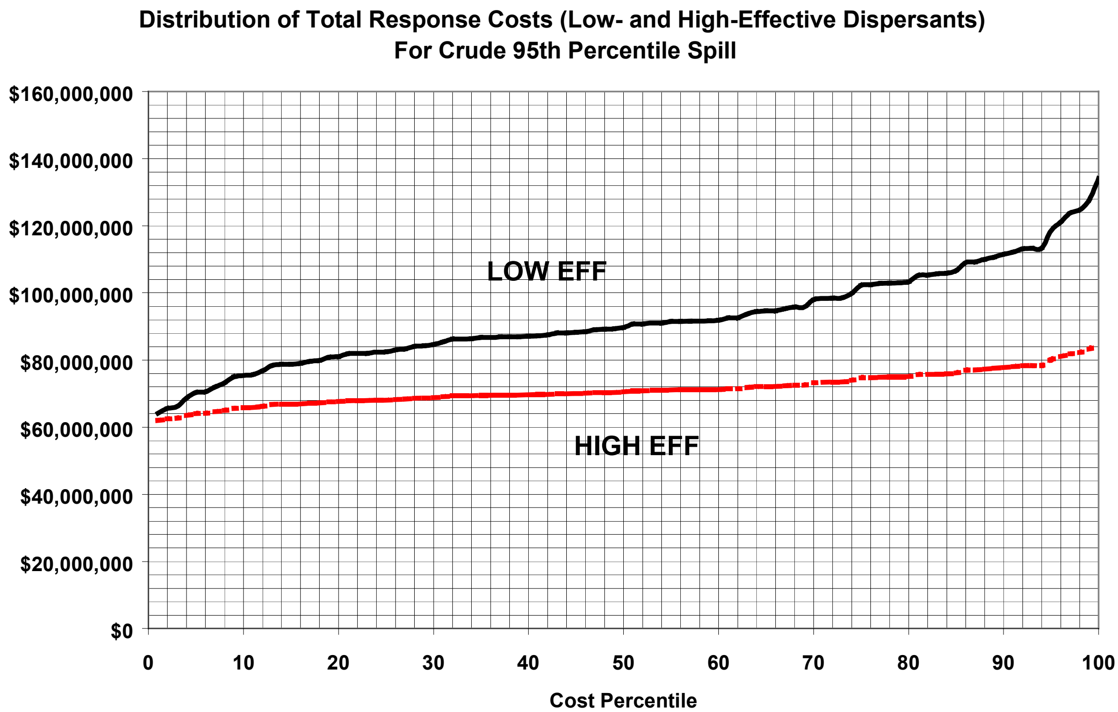

Distribution of Total Response Costs (Low- and High-Effective Dispersants)
For Crude 95th Percentile Spill
$160,000,000
$140,000,000
$120,000,000
$100,000,000
$80,000,000
$60,000,000
$40,000,000
$20,000,000
$0
0
10
20
30
40
50
60
70
80
90
100
Cost Percentile
LOW EFF
HIGH EFF

Table 25

Estimated Total Low Effectiveness Dispersant Response Costs For Oil Spills In San Francisco Bay (including shoreline response, salvage, disposal, spill management)				
Oil	**Percentile (Gallons)**	**Minimum 1st percentile**	**Median 50th percentile**	**Maximum 99th percentile**
Diesel	**20th (50,000)**	$9,317,558	$10,668,302	$12,162,057
	50th (270,000)	$9,951,555	$21,437,173	$26,904,741
	95th (1,250,000)	$13,374,520	$22,459,748	$30,739,837
Gasoline	**20th (50,000)**	$9,273,000	$9,281,310	$9,308,615
	50th (270,000)	$9,723,022	$9,785,921	$10,076,789
	95th (1,250,000)	$11,893,013	$12,553,681	$13,225,049
Heavy Fuel Oil	**20th (25,000)**	$6,167,422	$8,043,523	$10,244,230
	50th (100,000)	$9,168,714	$21,220,811	$38,644,418
	95th (410,000)	$16,044,517	$44,307,473	$81,202,458
Crude	**20th (100,000)**	$14,922,456	$19,467,079	$25,801,128
	50th (600,000)	$23,153,176	$35,231,630	$52,634,448
	95th (3,000,000)	$64,165,594	$89,745,694	$134,133,442

Table 26

Estimated Total High-Effectiveness Dispersant Response Costs For Oil Spills In San Francisco Bay (including shoreline response, salvage, disposal, spill management)				
Oil	**Percentile (Gallons)**	**Minimum** **1st percentile**	**Median** **50th percentile**	**Maximum** **99th percentile**
Diesel	**20th (50,000)**	\$9,317,519	\$9,767,767	\$10,265,686
	50th (270,000)	\$9,951,518	\$13,780,058	\$15,602,580
	95th (1,250,000)	\$13,374,507	\$16,402,916	\$19,162,946
Gasoline	**20th (50,000)**	\$9,273,000	\$9,275,770	\$9,284,872
	50th (270,000)	\$9,723,007	\$9,743,974	\$9,840,930
	95th (1,250,000)	\$11,893,004	\$12,113,227	\$12,337,016
Heavy Fuel Oil	**20th (25,000)**	\$5,996,502	\$6,862,395	\$7,878,106
	50th (100,000)	\$8,387,560	\$13,950,067	\$21,991,731
	95th (410,000)	\$14,762,700	\$27,807,141	\$44,835,596
Crude	**20th (100,000)**	\$14,550,152	\$16,065,026	\$18,176,376
	50th (600,000)	\$22,537,725	\$26,563,877	\$32,364,816
	95th (3,000,000)	\$61,970,531	\$70,497,231	\$85,293,147

The maximum (99th percentile) response costs (in terms of maximum shoreline oiling) as calculated above for dispersant use and mechanical recovery can be treated as the figures in Table 23 to estimate maximum response costs based on errors and ineffective responses. The results are shown in Table 27.

Table 27

Estimated Maximum Total Response Costs (and Per-Gallon Costs) For Oil Spills In San Francisco Bay (including shoreline response) Using 99th percentile Shoreline Impact			
Scenario		**Primary On-Water Response Strategy**	
Oil Type	**Percentile (Gallons)**	**Mechanical[1]**	**Dispersants[2]**
Diesel	**20th (50,000)**	$20,812,999 ($416/gal)	$20,897,999 ($418/gal)
	50th (270,000)	$55,637,263 ($206/gal)	$56,113,263 (208/gal)
	95th (1,250,000)	$61,973,419 ($50/gal)	$64,535,419 ($52/gal)
Gasoline	**20th (50,000)**	$14,090,101 ($282/gal)	$14,183,101 ($284/gal)
	50th (270,000)	$16,077,109 ($60/gal)	$16,526,109 ($61/gal)
	95th (1,250,000)	$21,457,913 ($17/gal)	$23,450,913 ($19/gal)
Heavy Fuel Oil	**20th (25,000)**	$21,013,096 ($841/gal)	$21,083,096 ($843/gal)
	50th (100,000)	$86,682,546 ($867/gal)	$86,880,546 ($869/gal)
	95th (410,000)	$188,793,248 ($460/gal)	$189,425,248 ($462/gal)
Crude	**20th (100,000)**	$56,141,232 ($561/gal)	$56,305,232 ($563/gal)
	50th (600,000)	$132,302,912 ($221/gal)	$133,332,912 ($222/gal)
	95th (3,000,000)	$358,574,630 ($120/gal)	$363,447,630 ($121/gal)

[1]Assumes that excessive mechanical recovery equipment and personnel mobilized creating overall increase in expenditures as found to occur in the PEPCO Pipeline spill in Maryland.
[2]Assumes that dispersant application carried out or mobilized is completely ineffective and that a concurrent or subsequent overabundant mechanical recovery effort is mobilized as under (1).

To obtain *maximum costs weighted by likely response strategy* for post-2004 spills (as described in Table 18), the values in Table 27 were treated with the appropriate weights for response type. The following assumptions were made:

- Dispersant application was attempted or mobilized;
- The dispersant application was *completely ineffective or not possible*, requiring a complete mechanical recovery effort;
- The mechanical recovery effort was also *completely ineffective*;
- The mechanical recovery effort was complicated to the extent that total costs were 40% higher than would be expected; *and*
- Shoreline impact was in the 99th percentile in terms of costs (i.e., the shoreline impacts were weighted based on the cost of cleaning up each shoreline type).

The resulting maximum values are shown in Tables 28 for the years 2001 – 2005 and Table 29 for 2006 – 2010. Corresponding per-gallon values are in Tables 30 –31.

Table 28

Total Estimated MAXIMUM Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2001 - 2005						
Scenario		**Total Projected Response Costs[2]**				
Oil	**Percentile**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	$20,812,999	$21,333,324	$21,895,275	$22,436,413	$23,094,385
	50th	$55,028,194	$57,028,194	$58,530,400	$59,976,969	$61,903,332
	95th	$61,973,419	$63,522,755	$65,196,037	$66,807,346	$70,242,745
Gasoline	**20th**	$14,090,101	$14,442,354	$14,822,786	$15,189,129	$15,665,938
	50th	$16,077,109	$16,479,036	$16,913,118	$17,331,123	$18,128,898
	95th	$21,457,913	$21,994,361	$22,573,725	$23,131,631	$25,055,007
Heavy Fuel Oil	**20th**	$21,013,096	$21,538,423	$22,105,777	$22,652,117	$23,302,420
	50th	$86,682,546	$88,849,609	$91,190,038	$93,443,784	$96,024,187
	95th	$188,793,248	$193,513,079	$198,610,497	$203,519,121	$209,294,627
Crude	**20th**	$56,141,232	$57,544,763	$59,060,576	$60,520,248	$62,219,171
	50th	$132,302,912	$135,610,485	$139,182,663	$142,622,539	$147,010,529
	95th	$358,574,630	$367,538,996	$377,220,511	$386,543,452	$399,817,264

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table 29

Total Estimated MAXIMUM Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2006 - 2010						
Scenario		**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	$23,683,873	$24,336,267	$24,900,283	$25,573,949	$26,205,025
	50th	$63,497,494	$65,261,043	$66,773,531	$68,595,240	$70,306,341
	95th	$72,311,573	$74,437,581	$76,162,744	$78,364,176	$80,445,503
Gasoline	**20th**	$16,067,817	$16,512,478	$16,895,171	$17,354,424	$17,784,443
	50th	$18,613,316	$19,148,300	$19,592,080	$20,145,521	$20,667,436
	95th	$25,915,317	$26,739,853	$27,359,575	$28,216,032	$29,032,562
Heavy Fuel Oil	**20th**	$23,896,323	$24,553,651	$25,122,706	$25,801,425	$26,437,324
	50th	$98,466,406	$101,169,702	$103,514,407	$106,305,435	$108,923,375
	95th	$214,629,059	$220,533,158	$225,644,227	$231,740,468	$237,460,008
Crude	**20th**	$63,803,639	$65,557,383	$67,076,739	$68,887,494	$70,586,195
	50th	$150,849,116	$155,032,855	$158,625,891	$162,947,340	$167,005,729
	95th	$410,491,818	$421,997,228	$431,777,421	$443,666,989	$454,846,717

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table 30

Total Estimated MAXIMUM Per-Gallon Response Cost Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2001 - 2005						
Scenario		**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	$416	$427	$438	$449	$462
	50th	$206	$211	$217	$222	$229
	95th	$50	$51	$52	$53	$56
Gasoline	**20th**	$282	$289	$296	$304	$313
	50th	$60	$61	$63	$64	$67
	95th	$17	$18	$18	$19	$20
Heavy Fuel Oil	**20th**	$841	$862	$884	$906	$932
	50th	$867	$888	$912	$934	$960
	95th	$460	$472	$484	$496	$510
Crude	**20th**	$561	$575	$591	$605	$622
	50th	$221	$226	$232	$238	$245
	95th	$120	$123	$126	$129	$133

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Table 31

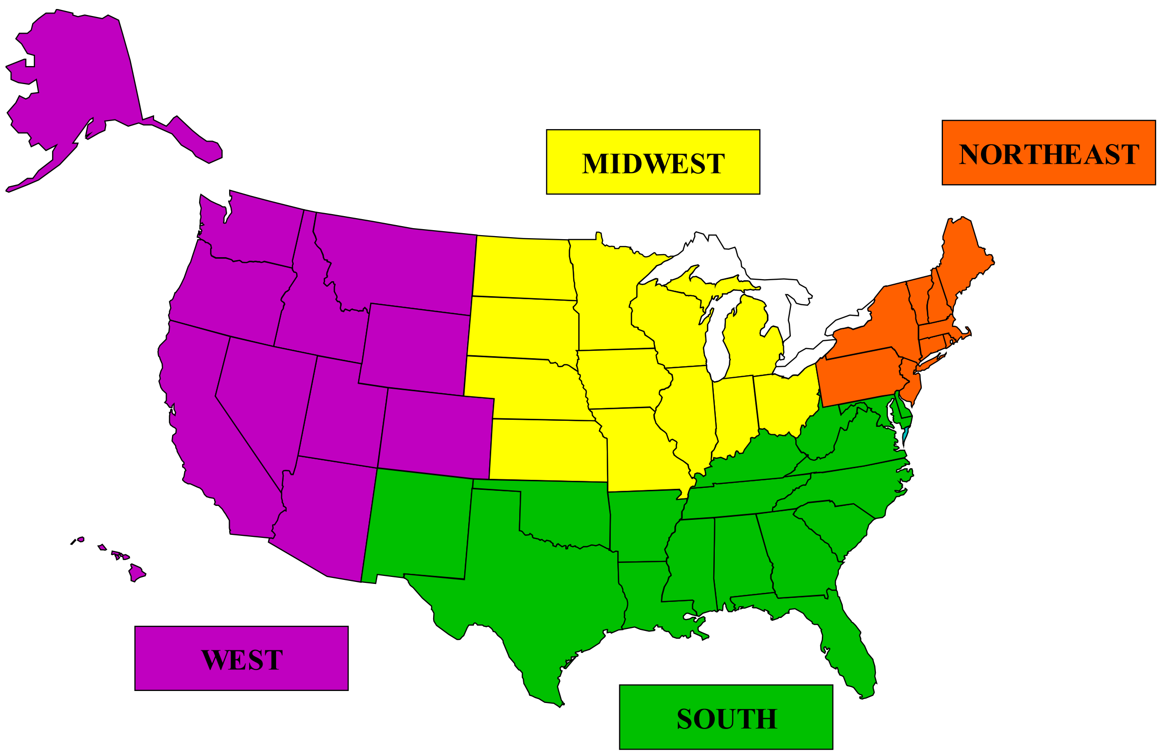
Total Estimated MAXIMUM Response Cost (per gallon) Values For Oil Spills in San Francisco Bay Based on Weighting by Most Probable Response Methodologies[1] 2006 - 2010						
Scenario		**Total Projected Response Costs[2]**				
Oil Type	**Percentile**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	$474	$487	$498	$511	$524
	50th	$235	$242	$247	$254	$260
	95th	$58	$60	$61	$63	$64
Gasoline	**20th**	$321	$330	$338	$347	$356
	50th	$69	$71	$73	$75	$77
	95th	$21	$21	$22	$23	$23
Heavy Fuel Oil	**20th**	$956	$982	$1,005	$1,032	$1,057
	50th	$985	$1,012	$1,035	$1,063	$1,089
	95th	$523	$538	$550	$565	$579
Crude	**20th**	$638	$656	$671	$689	$706
	50th	$251	$258	$264	$272	$278
	95th	$137	$141	$144	$148	$152

[1]Most probable combination of response methodologies as shown in Table 18.
[2]Costs for years past 2001 are projected based on cost in 2001 dollars multiplied by cost adjustment factors in Table A.

Appendix A

US Regional Cost Adjustment Factors		
Urban Area	**CPI (82-84 = 100) 1st half 2000**	**Regional Adjustment Factor (multiply cost by factor)**
Anchorage	154.4	0.87
Atlanta	176.1	1.00
Boston	190.5	1.08
Chicago	178.5	1.01
Cincinnati	167.2	0.95
Cleveland	172.6	0.98
Dallas	168.9	0.96
Denver	180.7	1.02
Detroit	174.1	0.99
Honolulu	178.1	1.01
Houston	168.9	0.96
Kansas City	171.9	0.97
Los Angeles	176.5	1.00
Miami	172.4	0.98
Milwaukee	171.8	0.97
Minneapolis	175.3	0.99
New York City	186.5	1.06
Philadelphia	180.5	1.02
Pittsburgh	172.4	0.98
Portland	181.2	1.03
San Diego	190.1	1.08
San Francisco	188.7	1.07
Seattle	184.4	1.04
St. Louis	167.5	0.95
Tampa	171.7	0.97
Washington DC/Baltimore	179.9	1.02
ALL US	**176.6**	**1.00**
Western US	**180.2**	**1.02**
Midwestern US	**172.8**	**0.98**
Southern US	**170.9**	**0.97**
Northeastern US	**183.8**	**1.04**
Consumer Price Indices from US Bureau of Labor Statistics (personal communication) Analysis by Environmental Research Consulting		

Future Dollar Valuation (from 2001 $)	
Year	**Conversion Factor**
2001	1.000
2002	1.025
2003	1.052
2004	1.078
2005	1.106
2006	1.134
2007	1.865
2008	1.192
2009	1.224
2010	1.254
Adapted from Robert Sahr, Political Science Dept., Oregon State University, Corvallis, OR (unpublished report)	



Appendix B

USCG Standard Hourly Rates for Personnel (2001 Dollars)		
Category	**Within Government**	**Outside Government**
0-5/6, GS/GM-14/15	$56	$67
0-3/4, GS/GM-12/13, CWO	$41	$49
0-1/2, GS-9 through 11	$31	$35
E-6 through 9, GS-5 through 8	$27	$31
E-1 through 5, GS-1 through 4	$19	$22
Wageboard	$29	$32
Officers/Civilians/CWO (when grade distribution unknown)	$38	$45
Enlisted (when grade distribution unknown)	$22	$24
[Note: Hourly rates for different categories of personnel service reflect the average recurring personnel related USCG costs including pay, allowances, government contribution to employee benefits (FICA, medical, etc.), training, permanent changes of station, and incurred but unrefunded retirement cost. Charges for normal crews are included in rates for cutters, small boats, and aircraft.]		

Oil Spill Removal Organization Resource Requirements (Nearshore Environment)		
Resource Type	**Maximum Most Probable Discharge[1]**	**Worst-Case Discharge[2]**
Protective Boom	8,000 feet	30,000 feet
Effective Daily Recovery Capacity (Skimmers)	50,400 gallons	2.1 million gallons
Temporary Storage Capacity	100,800 gallons	4.2 million gallons
Containment Boom	1,000 ft plus 300 feet per skimming system	1,000 ft plus 300 feet per skimming system
[1]For tank vessels with capacity equal to or greater than 1.05 million gallons, maximum most probable discharge for vessels is 105,000 gallons. For vessels with less than 1.05 million-gallon capacity, maximum most probable discharge is 10% of tank's capacity. [2]Worst-case discharge for tank vessels is entire cargo (generally 80% of tanker capacity). Source: *Guidelines for the USCG Oil Spill Removal Organization Classification Program*, May 2001 (US Coast Guard 2001)		

USCG Hourly Standard Rates for Cutters (2001 Dollars)					
Cutter Type	Facility Cost[1]	Field Operational Support[2]	Administrative Support[3]	Depreciation[4]	Total
Within Government					
WAGB	$2,764	--	$829	$436	$4,029
WHEC	$2,222	--	$667	$345	$3,235
WMEC	$1,255	--	$376	$201	$1,831
WLB	$1,004	--	$302	$20	$1,326
WLM	$754	--	$226	$23	$1,003
WTGB	$631	$121	$226	$159	$881
WSES	$256	$54	$92	$89	$490
WTYL	$238	$49	$86	$7	$379
WLI	$365	$58	$127	$5	$555
WLIC	$351	$65	$125	$5	$557
WLR	$389	$96	$145	$5	$635
WPB	$324	$83	$121	$102	$631
Outside Government					
WAGB	$2,943	--	$883	$436	$4,262
WHEC	$2,466	--	$740	$345	$3,551
WMEC	$1,390	--	$417	$201	$2,006
WLB	$1,082	--	$324	$20	$1,428
WLM	$812	--	$244	$23	$1,079
WTGB	$682	$121	$241	$159	$1,205
WSES	$277	$54	$99	$89	$518
WTYL	$253	$49	$91	$7	$401
WLI	$383	$58	$132	$5	$579
WLIC	$372	$65	$131	$5	$573
WLR	$417	$96	$154	$5	$673
WPB	$356	$83	$132	$102	$674
[Note: Charges apply for every full and fractional hour of use.]					

[1]Facility costs include the direct cost elements of personnel, fuel, and maintenance. Standard rates also include a factor for administrative support. These rates can also be supplemented with out-of-pocket costs, such as: extra maintenance required due to extraordinary facility use or abuse, based on the actual costs of the additional materials and labor; incidental personnel expenses such as travel and per diem; and the costs of any special equipment purchased solely for the purpose of providing a reimbursable service. Personnel costs are considered fixed and include a factor for retirement costs. Fuel costs are variable and reflect the actual fuel costs per vessel operating hour. Maintenance costs are also considered variable and are based on the latest two-year average actual maintenance costs per vessel operating hour. The averaging technique normalizes year-to-year fluctuations.
[2]These costs encompass the group support costs allocated to assigned cutters. Resulting costs are related to the programmed operating hours for the specific vessel class.
[3]This rate is applied to the total of facility costs and field operational support. Administrative support is currently set at 30% of costs of services.
[4]Depreciation costs for equipment are based on average capitalized value converted to an hourly factor on the basis of estimated life and programmed flight hours.

USCG Hourly Standard Rates for Small Boats (2001 Dollars)				
Class/ Type	**Facility Cost[1]**	**Field Operational Support[2]**	**Administrative Support[3]**	**Total**
Within Government				
ANB	$213	$201	$124	$538
ATB	$132	$150	$84	$366
BU/BUSL	$175	$201	$113	$489
MCB	$275	$100	$112	$487
MLB	$197	$201	$119	$517
MSB	$375	$100	$143	$618
PWB	$136	$150	$86	$372
TSNB	$136	$150	$84	$366
UTB	$132	$150	$89	$383
UTM	$145	$150	$92	$401
Boats (16'->25')	$120	$100	$65	$286
Boats (under 16')	$95	$100	$58	$253
Outside Government				
ANB	$232	$201	$130	$562
ATB	$147	$150	$89	$385
BU/BUSL	$195	$201	$118	$513
MCB	$284	$100	$115	$499
MLB	$216	$201	$126	$543
MSB	$383	$100	$145	$628
PWB	$150	$150	$90	$390
TSNB	$147	$150	$89	$385
UTB	$159	$150	$92	$401
UTM	$173	$150	$97	$421
Boats (16'->25')	$130	$100	$70	$299
Boats (under 16')	$103	$100	$61	$266
[Note: Charges apply for every full and fractional hour of use.]				

[1]Facility costs include the direct cost elements of personnel, fuel, and maintenance. Standard rates also include a factor for administrative support. These rates can also be supplemented with out-of-pocket costs, such as: extra maintenance required due to extraordinary facility use or abuse, based on the actual costs of the additional materials and labor; incidental personnel expenses such as travel and per diem; and the costs of any special equipment purchased solely for the purpose of providing a reimbursable service. Personnel costs are considered fixed and include a factor for retirement costs. Fuel costs are variable and reflect the actual fuel costs per vessel operating hour. Maintenance costs are also considered variable and are based on the latest two-year average actual maintenance costs per vessel operating hour. The averaging technique normalizes year-to-year fluctuations.
[2]These costs encompass the group support costs allocated to assigned cutters. Resulting costs are related to the programmed operating hours for the specific vessel class.
[3]This rate is applied to the total of facility costs and field operational support. Administrative support is currently set at 30% of costs of services.
[4]Depreciation costs for equipment are based on average capitalized value converted to an hourly factor on the basis of estimated life and programmed flight hours.

USCG Hourly Standard Rates For Vehicles (2001 Dollars)		
Vehicle Type	**Daily Rate**	**Mileage Rate**
Automobiles	$11.55	$0.14
Light Trucks (4x2)	$10.26	$0.20
Light Trucks (4x4)	$11.55	$0.24
Carryall (4x2)	$10.26	$0.27
Step Vans and Medium Trucks (12,500-23,999 lbs. gross vehicle weight)	$17.95	$0.40
Heavy Trucks (≥24,000 lbs.)	$21.82	$0.20
Dump Trucks	$24.38	$11.19
[Note: Rates are applied for every full or fractional mile and day of use. If the vehicle is commercial or General Services Administration Lease, the actual rental charges are applied. The charge is obtained by obtaining a total of the mileage rate, daily rate, and applicable personnel charges.		

USCG Hourly Standard Rates for Aircraft (2001 Dollars)					
Class/Type	**Facility Cost[1]**	**Field Operational Support[2]**	**Administrative Support[3]**	**Depreciation[4]**	**Total**
Within Government					
HC-130	$2,537	$1,284	$1,146	$269	$5,236
HH-3F/3E	$2,189	$1,344	$1,060	$102	$4,696
HH-65A	$2,294	$1,020	$995	$359	$4,668
HU-25	$2,702	$628	$999	$526	$4,855
VC-4A	$1,855	$668	$757	$154	$3,435
VC-11A	$2,323	$1,054	$1,013	$308	$4,698
E-2C	$2,842	$959	$1,139	varies	$4,940+
Outside Government					
HC-130	$2,697	$1,284	$1,194	$269	$5,445
HH-3F/3E	$2,363	$1,344	$1,112	$102	$4,922
HH-65A	$2,421	$1,020	$1,033	$359	$4,833
HU-25	$2,804	$628	$1,031	$526	$4,989
VC-4A	$1,986	$668	$1,128	$154	$3,937
VC-11A	$2,451	$1,054	$1,051	$308	$4,864
E-2C	$3,000	$959	$1,188	varies	$5,147+
[Note: Charges apply for every full and fractional hour of use.]					
[1]Personnel costs are considered fixed. Fuel costs are variable and based on current actual fuel costs per aircraft hour. Maintenance costs are variable and based on the latest two-year average actual maintenance costs per aircraft flight hour. The averaging technique normalizes year-to-year fluctuations. [2]Operational support includes air station and group support, which are fixed. [3]This rate is applied to the total of facility costs and field operational support. Administrative support is currently set at 30% of costs of services. [4]Depreciation costs for equipment are based on average capitalized value converted to an hourly factor on the basis of estimated life and programmed flight hours.					

Summary of California Regional Mechanical Recovery Resources						
Region	Boom (Ft.)			Skimmer EDRC (gal/day)	Temporary Storage (gallons)	Vessel Storage (gallons)
	6-18 in.	19-41 in.	>42 in.			
California	112,600 ‘	363,874 ‘	113,070 ‘	12,252,660	25,925,844	22,213,128
Source: US Coast Guard Response Plan Equipment Caps Review Draft (~~August~~ 1999)						

Total Available Oil Removal Capability (Effective Daily Recovery Capacity) for Vessel Spills In Nearshore Areas Based on Inland Equipment			
Coastal Port	Tier I 10,000 bpd	Tier II 20,000 bpd	Tier III 40,000 bpd
San Francisco, CA	14,939,988 gal per day	29,289,876 gal per day	89,427,912 gal per day
Source: US Coast Guard Response Plan Equipment Caps Review Draft (~~August~~ 1999)			

Total Available Oil Removal Capability (Effective Daily Recovery Capacity) for Vessel Spills In Nearshore Areas Based on Ocean Equipment			
Coastal Port	Tier I 10,000 bpd	Tier II 20,000 bpd	Tier III 40,000 bpd
San Francisco, CA	14,939,988 gal per day	29,289,876 gal per day	89,427,912 gal per day
Source: US Coast Guard Response Plan Equipment Caps Review Draft (AugustUS Coast Guard 1999)			

USCG Hourly Standard Rates For Pollution Cleanup Equipment (1999 Dollars)					
Equipment	**Maintenance [1]**	**Field Operational Support [2]**	**Administrative Support [3]**	**Depreciation [4]**	**Total**
Inside Government					
Air-Deployable Antipollution Transfer System (ADAPTS)	$35	$29	$17	$48	$118
Skimming Barrier w/Prime Mover	$48	$34	$24	$59	$165
Skimming Barrier w/o Prime Mover	$25	$27	$16	$58	$127
Disk Drum Skimmer	$166	$127	$89	$313	$696
Type A Dracone	$327	$238	$169	$1,169	$1,903
Type F Dracone	$129	$94	$67	$447	$736
Type D Dracone	$65	$43	$32	$208	$348
Viscous Oil Pumping System (VOPS)	$41	$18	$18	$40	$117
Lockheed Cold Weather Skimmer	$25	$19	$14	$45	$103
Cold Weather Boom (per 400 ft. pallet)	$8	$5	$4	$27	$46
Van Mobilizer	$6	$3	$2	$7	$19
Lockheed 110 Skimmer	$4	$1	$1	$1	$7
Organic Vapor Analyzer	$2	$1	$1	$10	$14
Photoionizer	$2	$2	$1	$5	$11
Combustible Gas Indicator	$3	$10	$4	$2	$19
60-Minute Self Contained Breathing Apparatus	$2	$2	$1	$1	$6
Containment Boom (Open Water)	$26	$25	$16	$38	$106
Infrared Pyrometer	$2	$116	$36	$2	$129
Outside Government					
Air-Deployable Antipollution Transfer System (ADAPTS)	$38	$19	$18	$46	$124
Skimming Barrier w/Prime Mover	$53	$34	$25	$59	$171
Skimming Barrier w/o Prime Mover	$29	$27	$16	$58	$130
Disk Drum Skimmer	$187	$127	$94	$313	$720
Type A Dracone	$365	$238	$181	$1,169	$1,953
Type F Dracone	$144	$95	$72	$447	$757
Type D Dracone	$73	$43	$35	$208	$359
Viscous Oil Pumping System (VOPS)	$46	$18	$19	$40	$124
Lockheed Cold Weather Skimmer	$29	$19	$14	$45	$107
Cold Weather Boom (per 400 ft. pallet)	$11	$5	$5	$27	$49
Van Mobilizer	$8	$2	$2	$7	$20
Lockheed 110 Skimmer	$4	$1	$1	$1	$7
Organic Vapor Analyzer	$2	$1	$1	$10	$14
Photoionizer	$2	$1	$1	$5	$10
Combustible Gas Indicator	$4	$10	$3	$2	$19
60-Minute Self Contained Breathing Apparatus	$3	$1	$1	$1	$6
Containment Boom (Open Water)	$29	$25	$17	$38	$109
Infrared Pyrometer	$2	$114	$36	$2	$156

[Mobile command post charges calculated on basis of standard medium truck rates estimated at $0.40 per mile and $18 per day.)

[1] Labor costs are computed on the basis of projected annual maintenance hours for the specific types of equipment and current standard personnel rates. An additional factor for unrefunded retirement costs is included for non-government work. Maintenance supplies and materials are allocated to specific equipment items and based on two-year average of relative costs.

[2] This amount, allocated for specific equipment items, is based on the Strike Team's latest two-year average actual OG-30 costs, less travel, transportation, and equipment maintenance, adjusted for inflation.

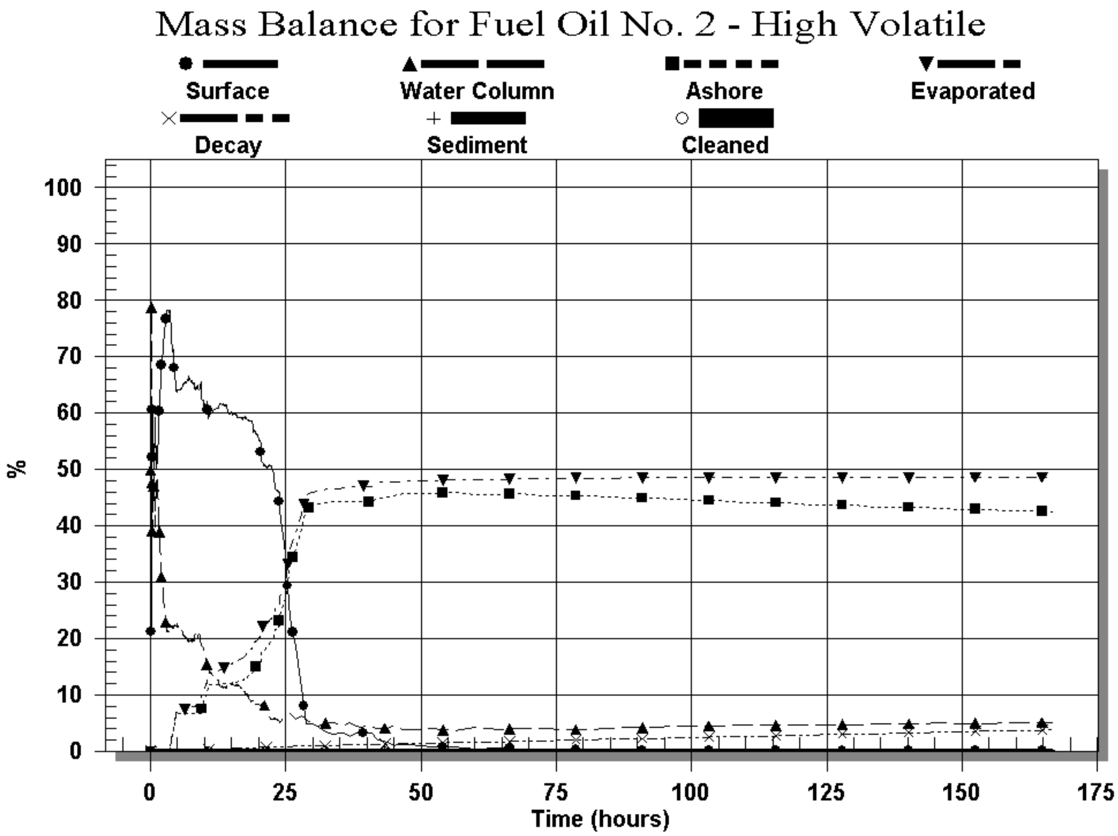
[3] This rate is applied to total facility costs and field operational support. Administrative support is set at 30% of costs of services.

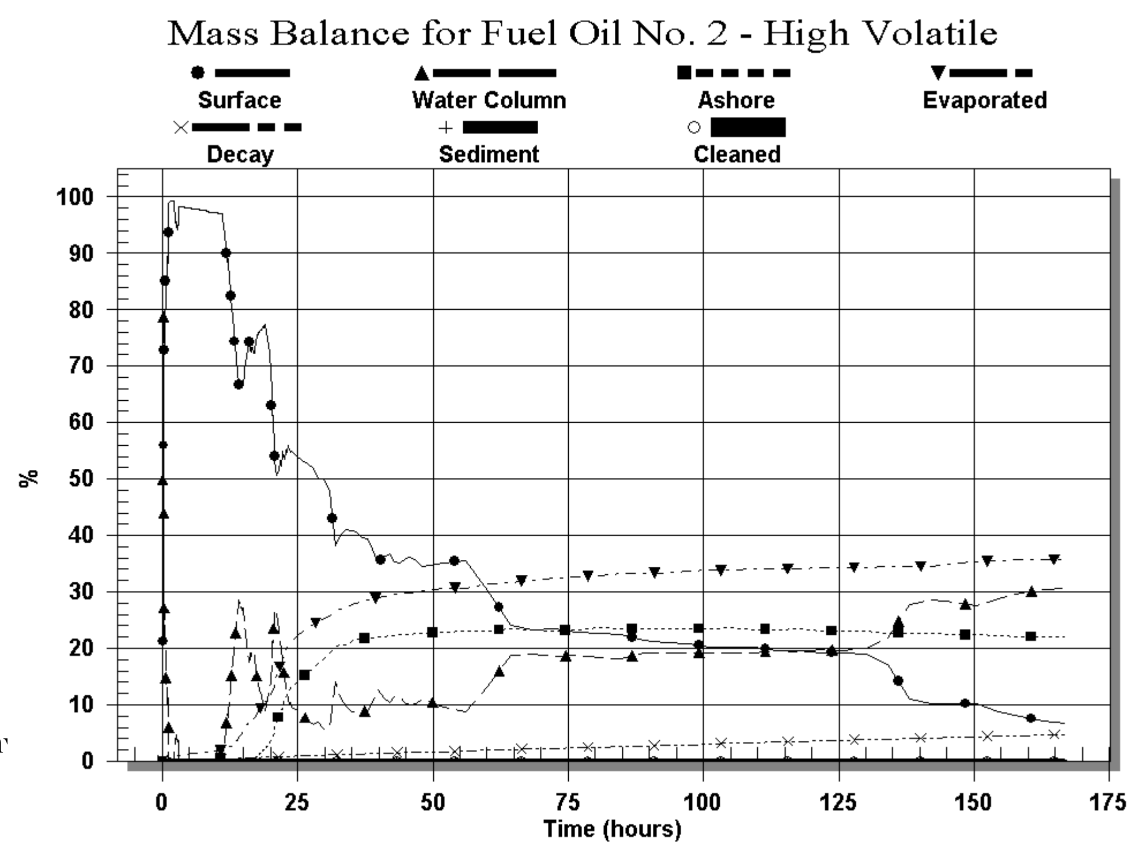
[4] Depreciation calculated as average capitalized value converted to hourly factor on basis of estimated life/annual usage.

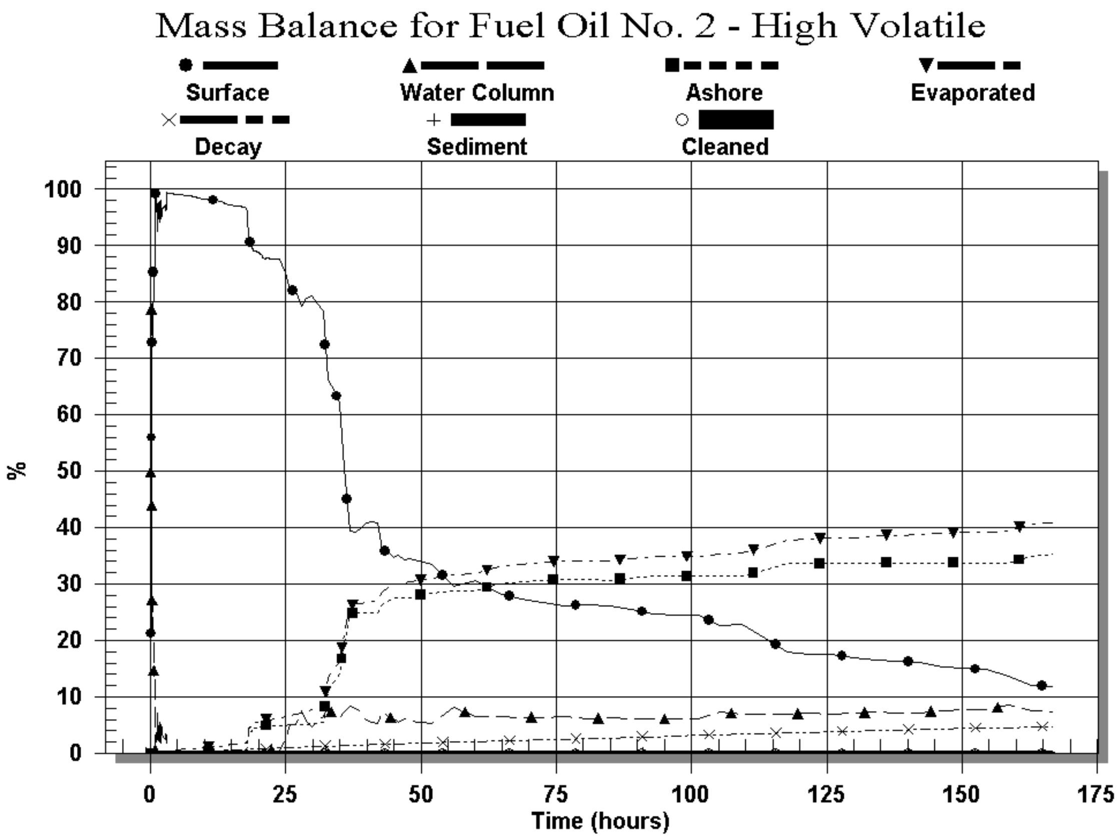
[Note: Charges are applied for every full or fractional use hour, excluding transit time with separate charges for: (1) the cost of USCG Strike Team personnel operating and/or supervising the operations of the equipment based on the standard rates for personnel; (2) actual fuel costs associated with operational use of the equipment; (3) the cost of transporting the equipment to and from the job site; and (4) the actual reimbursement costs when performed by a contractor.

Appendix C:

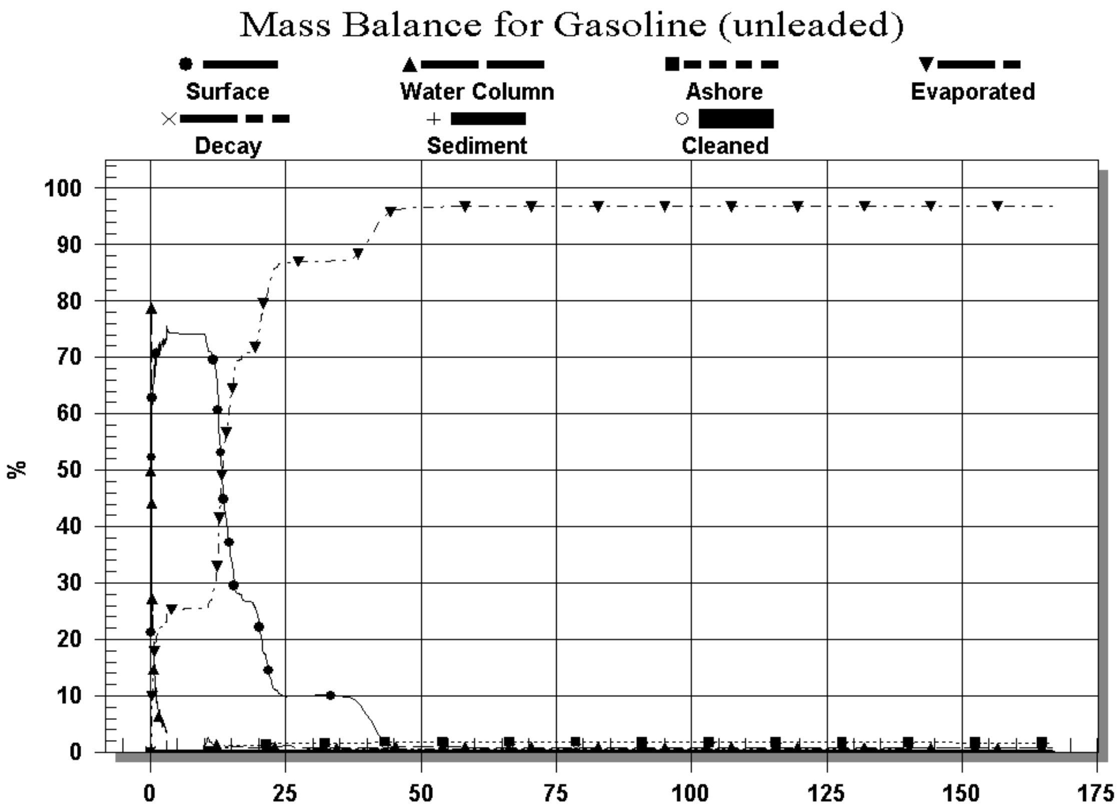
Mass Balance for Diesel Spills for 20th, 50th, and 95th Percentile Volumes

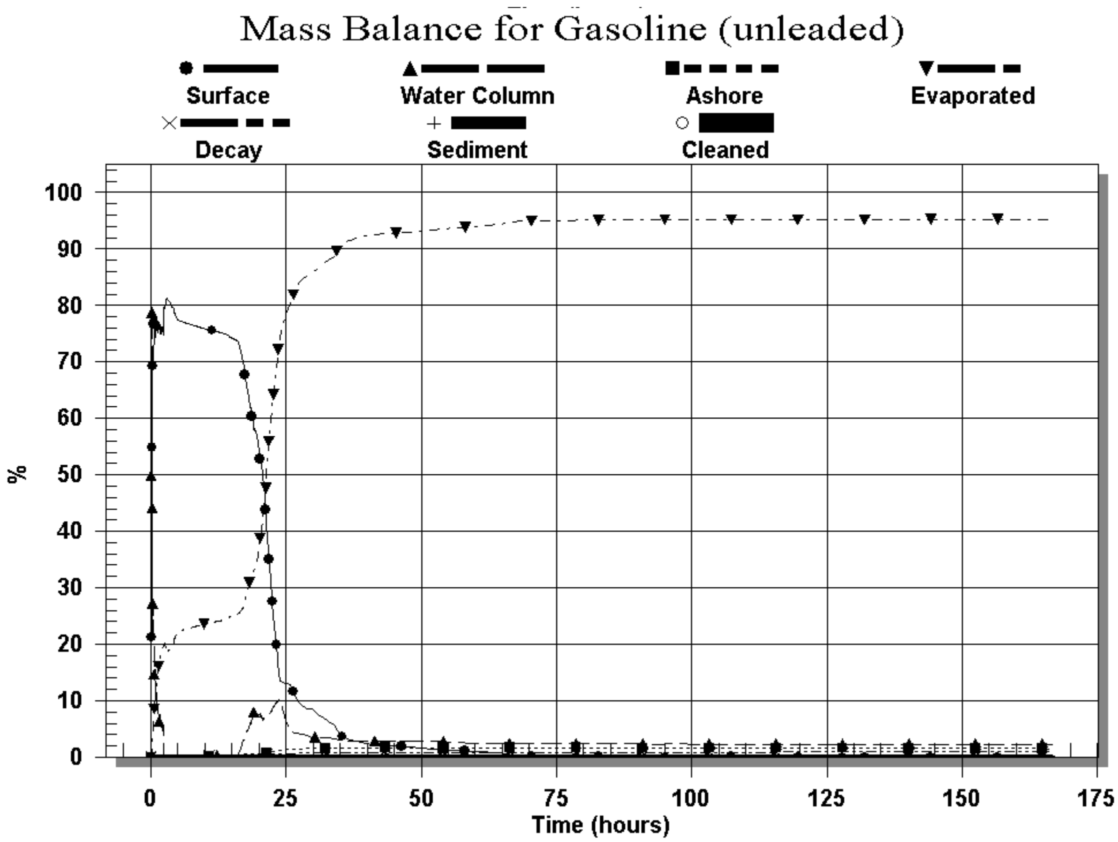


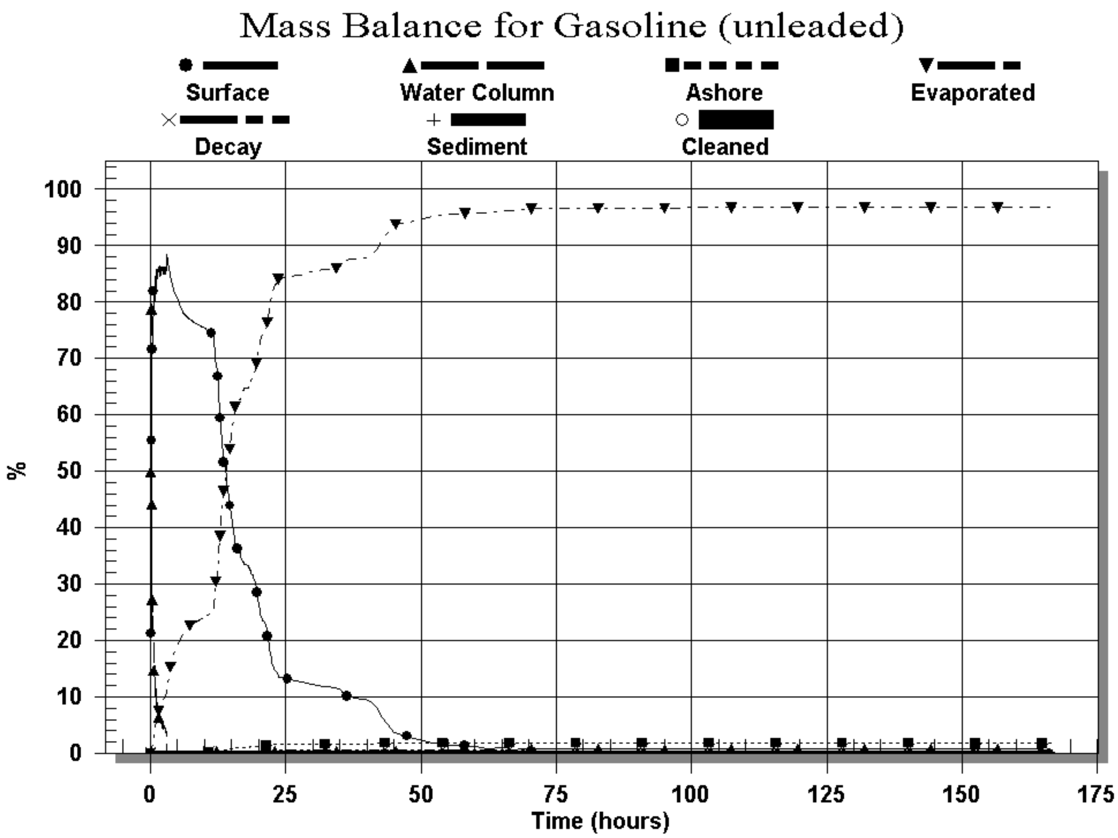



Mass Balance for Fuel Oil No. 2 - High Volatile
Surface
Water Column
Ashore
Evaporated
Decay
Sediment
Cleaned
100
90
80
70
60
50
40
30
20
10
0
%
0
25
50
75
100
125
150
175
Time (hours)

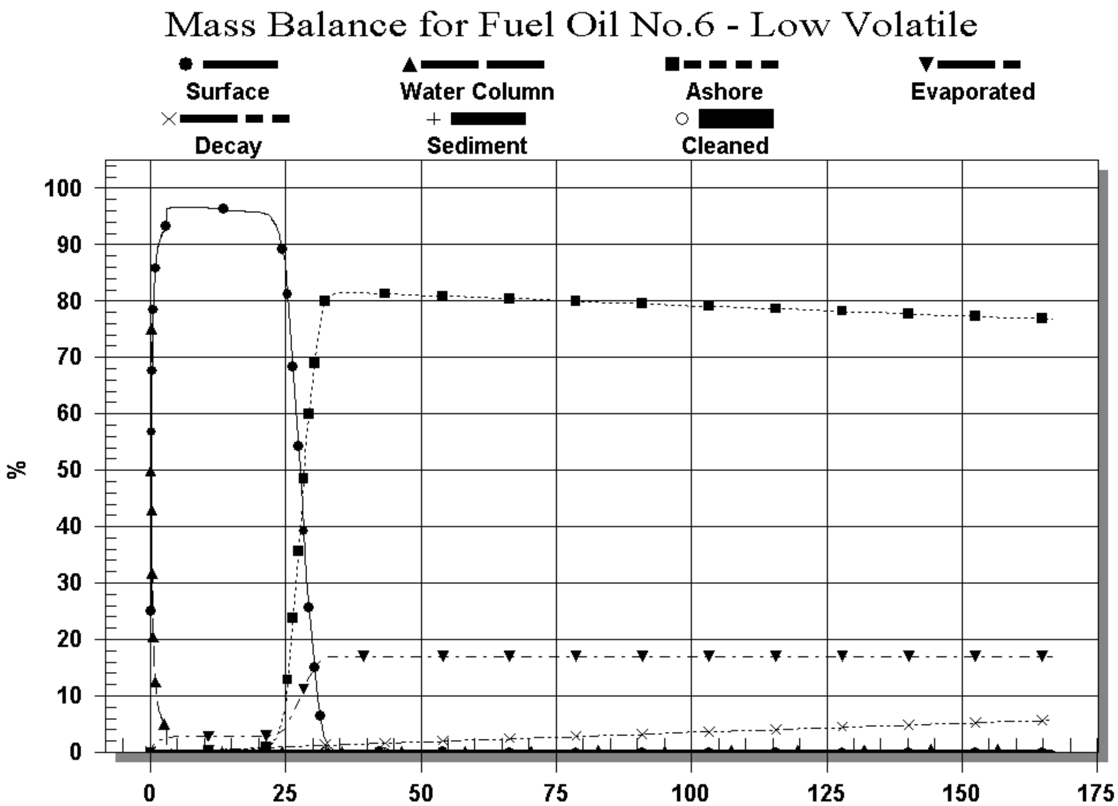
Mass Balance for Gasolline Spills for 20th, 50th, and 95th Percentile Volumes

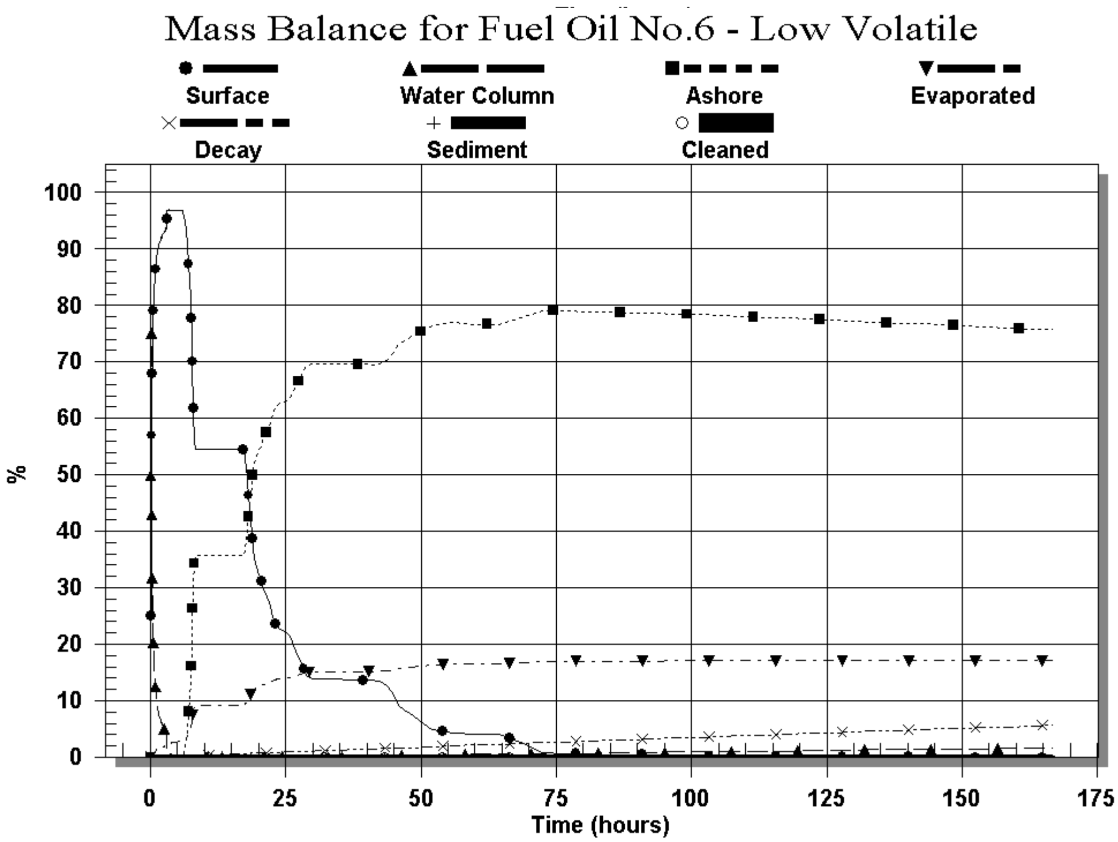


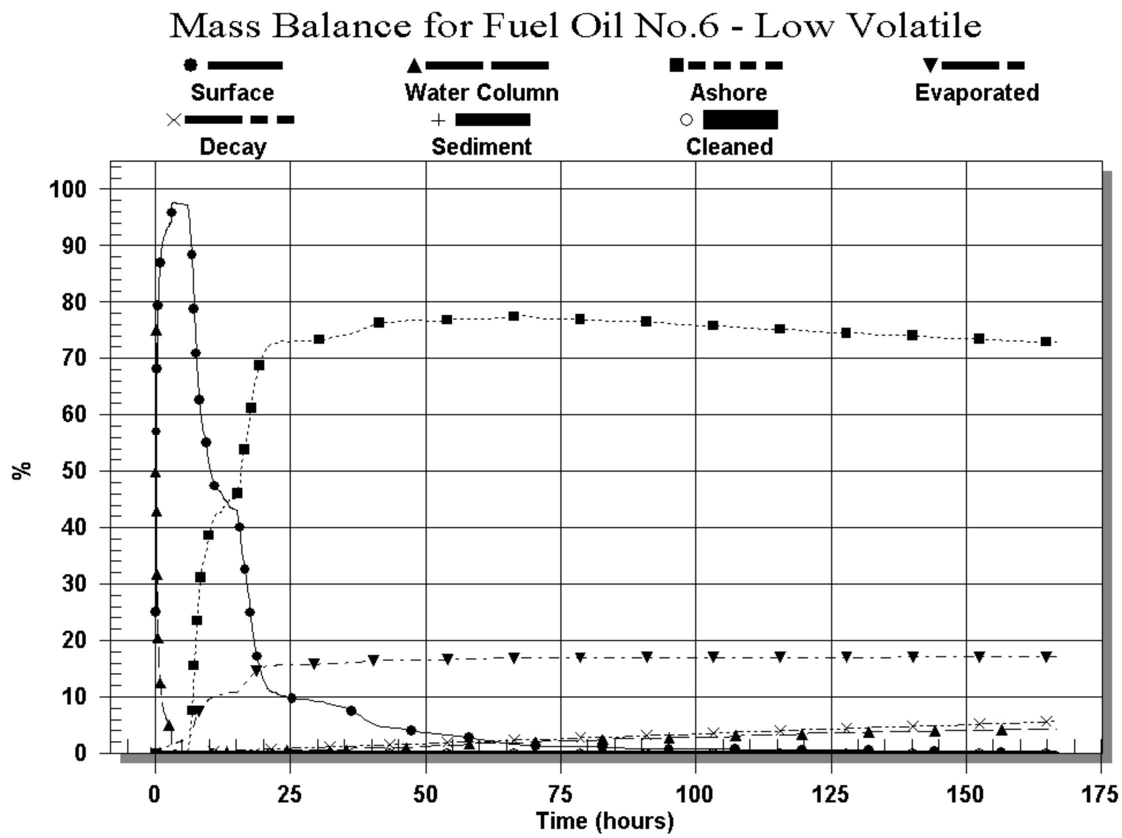



Mass Balance for Gasoline (unleaded)
Surface
Water Column
Ashore
Evaporated
Decay
Sediment
Cleaned
100
90
80
70
60
50
40
30
20
10
0
%
0
25
50
75
100
125
150
175
Time (hours)

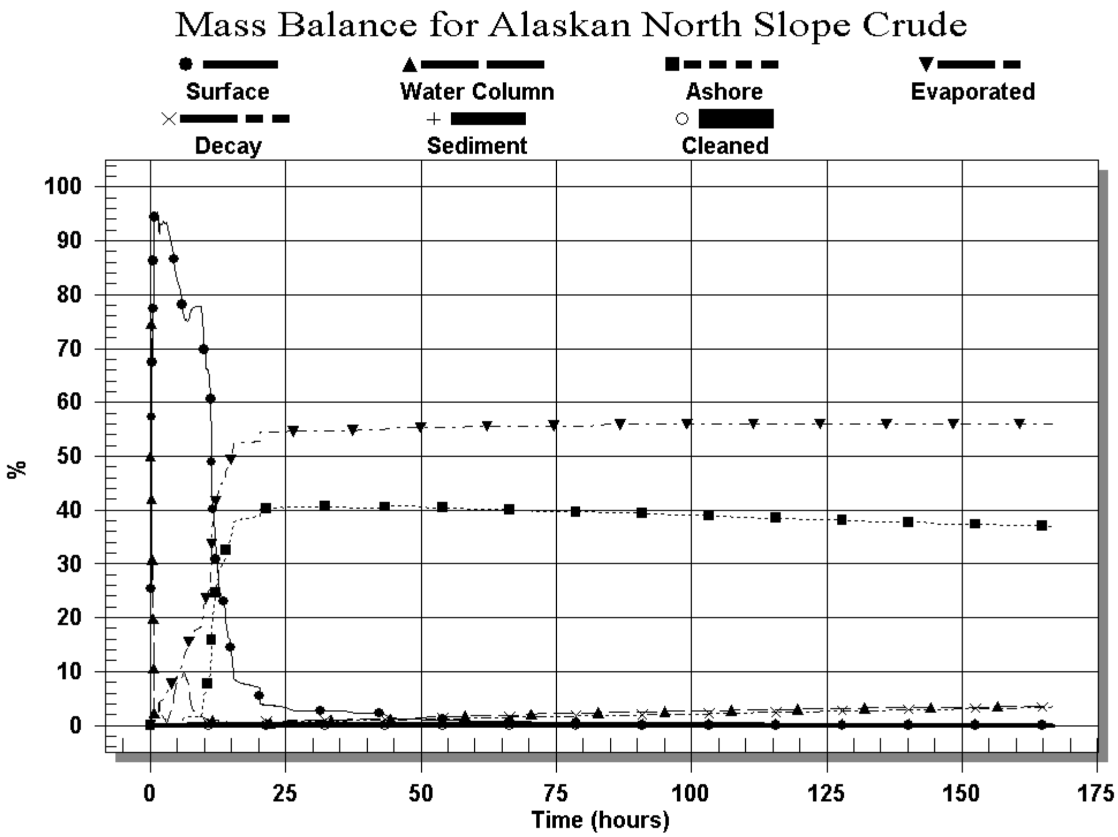
Mass Balance for HFO Spills for 20th, 50th, and 95th Percentile Volumes

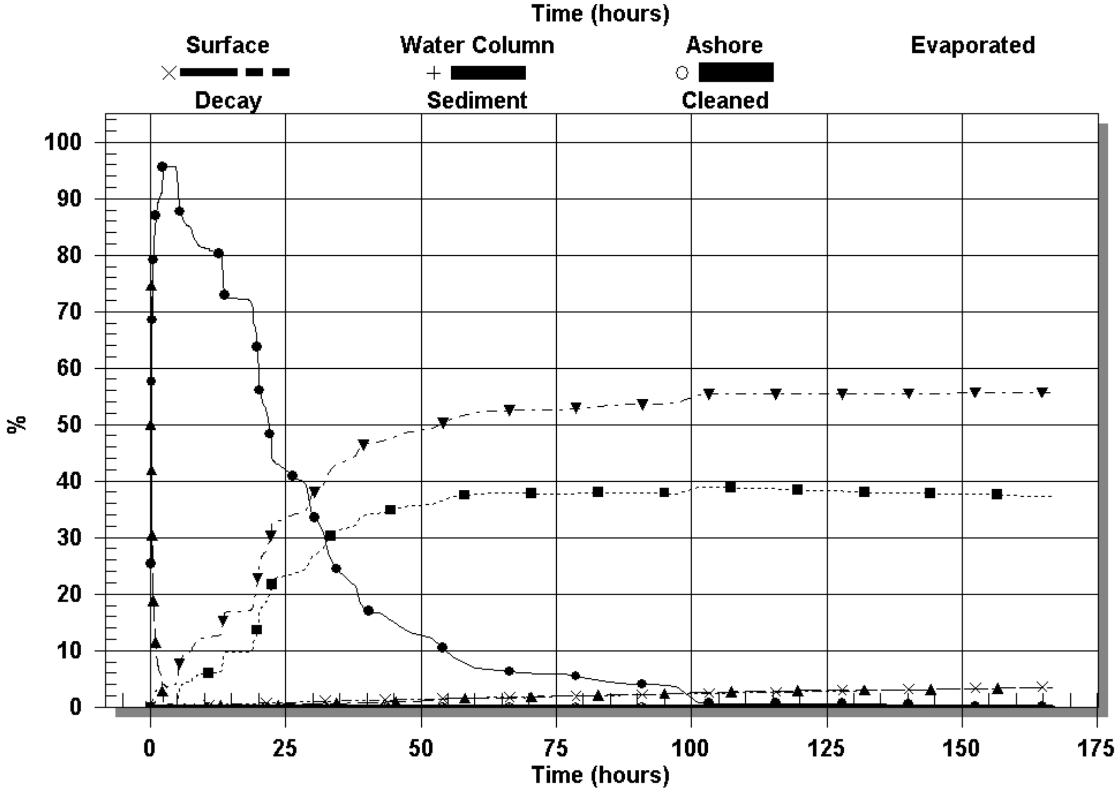


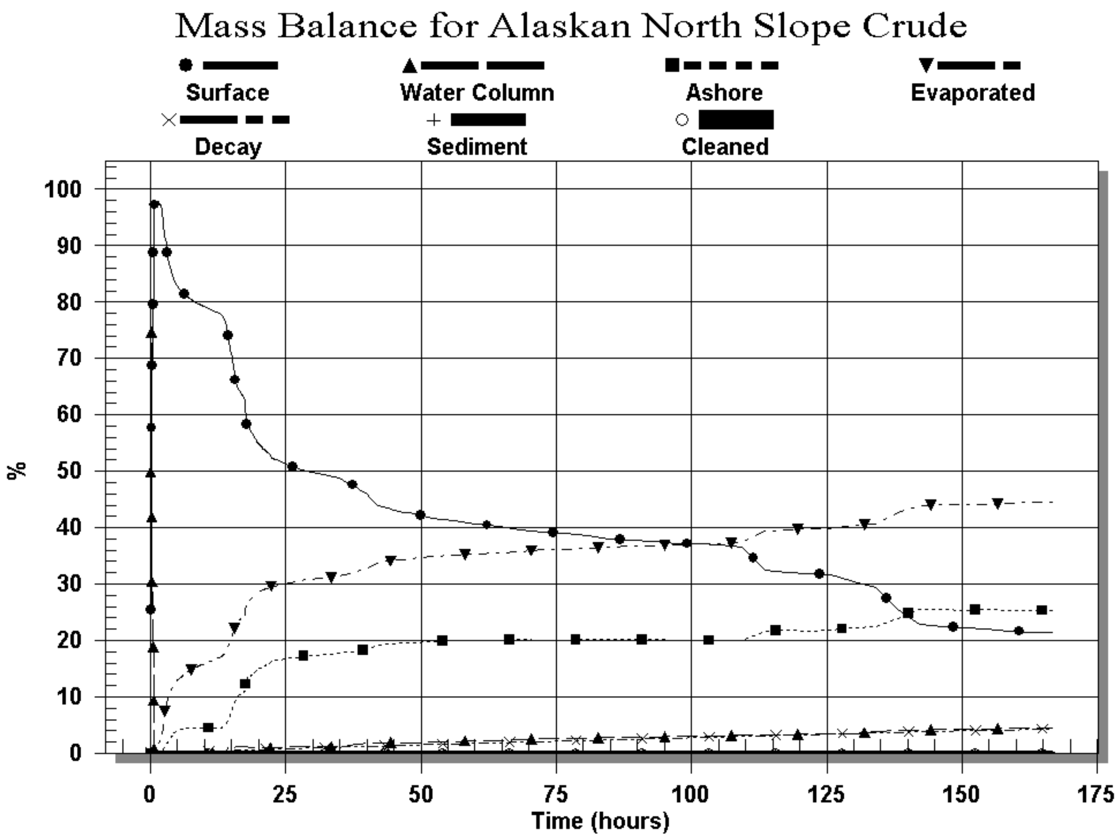



Mass Balance for Fuel Oil No.6 - Low Volatile
Surface
Water Column
Ashore
Evaporated
Decay
Sediment
Cleaned
100
90
80
70
60
50
40
30
20
10
0
%
0
25
50
75
100
125
150
175
Time (hours)

Mass Balance for Crude Spills for 20th, 50th, and 95th Percentile Volumes







Mass Balance for Alaskan North Slope Crude
Surface
Water Column
Ashore
Evaporated
Decay
Sediment
Cleaned
100
90
80
70
60
50
40
30
20
10
0
%
0
25
50
75
100
125
150
175
Time (hours)

Appendix D

Total Estimated Response Costs For Oil Spills in San Francisco Bay With Primary Mechanical Recovery Operations (Including Shoreline Cleanup)							
Scenario			Total Projected Response Costs				
Oil Type	Percentile	Shoreline Impact[1]	2001	2002	2003	2004	2005
Diesel	20th	*median*	$12,205,500	$12,511,000	$12,840,000	$13,158,000	$13,499,000
		worst	$14,385,500	$14,745,000	$15,134,000	$15,508,000	$15,910,000
	50th	*median*	$18,788,500	$19,258,000	$19,766,000	$20,254,000	$20,780,000
		worst	$13,078,500	$13,405,000	$13,759,000	$14,099,000	$14,465,000
	95th	*median*	$26,894,500	$27,567,000	$28,293,000	$28,992,000	$29,745,000
		worst	$31,664,500	$32,456,000	$33,311,000	$34,134,000	$35,021,000
Gasoline	20th	*median*	$10,021,000	$10,272,000	$10,542,000	$10,803,000	$11,083,000
		worst	$10,007,000	$10,257,000	$10,527,000	$10,788,000	$11,068,000
	50th	*median*	$11,044,000	$11,320,000	$11,618,000	$11,905,000	$12,215,000
		worst	$11,010,000	$11,285,000	$11,583,000	$11,869,000	$12,177,000
	95th	*median*	$13,402,000	$13,737,000	$14,099,000	$14,447,000	$14,823,000
		worst	$15,025,000	$15,401,000	$15,806,000	$16,197,000	$16,618,000
Heavy Fuel Oil	20th	*median*	$11,619,000	$11,909,000	$12,223,000	$12,525,000	$12,851,000
		worst	$13,919,000	$14,267,000	$14,643,000	$15,005,000	$15,394,000
	50th	*median*	$35,107,000	$35,985,000	$36,933,000	$37,845,000	$38,828,000
		worst	$50,537,000	$51,800,000	$53,165,000	$54,479,000	$55,894,000
	95th	*median*	$78,087,000	$80,039,000	$82,148,000	$84,178,000	$86,364,000
		worst	$122,207,000	$125,262,000	$128,562,000	$131,739,000	$135,161,000
Crude	20th	*median*	$29,549,000	$30,288,000	$31,086,000	$31,854,000	$32,681,000
		worst	$36,029,000	$36,930,000	$37,903,000	$38,839,000	$39,848,000
	50th	*median*	$65,498,000	$67,135,000	$68,904,000	$70,607,000	$72,441,000
		worst	$83,698,000	$85,790,000	$88,050,000	$90,226,000	$92,570,000
	95th	*median*	$182,144,000	$186,698,000	$191,615,000	$196,351,000	$201,451,000
		worst	$230,184,000	$235,939,000	$242,154,000	$248,138,000	$254,584,000
[1]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.							

Total Estimated Response Costs For Oil Spills in San Francisco Bay With Primary Mechanical Recovery Operations (Including Shoreline Cleanup)							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1]**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$13,841,000	$14,219,000	$14,549,000	$14,940,000	$15,306,000
		worst	$16,313,000	$16,759,000	$17,148,000	$17,608,000	$18,039,000
	50th	***median***	$21,306,000	$21,889,000	$22,396,000	$22,997,000	$23,561,000
		worst	$14,831,000	$15,236,000	$15,590,000	$16,008,000	$16,400,000
	95th	***median***	$30,498,000	$31,332,000	$32,058,000	$32,919,000	$33,726,000
		worst	$35,908,000	$36,889,000	$37,744,000	$38,757,000	$39,707,000
Gasoline	**20th**	***median***	$11,364,000	$11,674,000	$11,945,000	$12,266,000	$12,566,000
		worst	$11,348,000	$11,658,000	$11,928,000	$12,249,000	$12,549,000
	50th	***median***	$12,524,000	$12,866,000	$13,164,000	$13,518,000	$13,849,000
		worst	$12,485,000	$12,827,000	$13,124,000	$13,476,000	$13,807,000
	95th	***median***	$15,198,000	$15,613,000	$15,975,000	$16,404,000	$16,806,000
		worst	$17,038,000	$17,504,000	$17,910,000	$18,391,000	$18,841,000
Heavy Fuel Oil	**20th**	***median***	$13,176,000	$13,536,000	$13,850,000	$14,222,000	$14,570,000
		worst	$15,784,000	$16,216,000	$16,591,000	$17,037,000	$17,454,000
	50th	***median***	$39,811,000	$40,900,000	$41,848,000	$42,971,000	$44,024,000
		worst	$57,309,000	$58,876,000	$60,240,000	$61,857,000	$63,373,000
	95th	***median***	$88,551,000	$90,971,000	$93,080,000	$95,578,000	$97,921,000
		worst	$138,583,000	$142,371,000	$145,671,000	$149,581,000	$153,248,000
Crude	**20th**	***median***	$33,509,000	$34,425,000	$35,222,000	$36,168,000	$37,054,000
		worst	$40,857,000	$41,974,000	$42,947,000	$44,099,000	$45,180,000
	50th	***median***	$74,275,000	$76,305,000	$78,074,000	$80,170,000	$82,134,000
		worst	$94,914,000	$97,508,000	$99,768,000	$102,446,000	$104,957,000
	95th	***median***	$206,551,000	$212,198,000	$217,116,000	$222,944,000	$228,409,000
		worst	$261,029,000	$268,164,000	$274,379,000	$281,745,000	$288,651,000

[1]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Total Estimated Per-Gallon Response Costs For Oil Spills in San Francisco Bay With Primary Mechanical Recovery Operations (Including Shoreline Cleanup)							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact**[1]	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	***median***	$244	$250	$257	$263	$270
		worst	$288	$295	$303	$310	$318
	50th	***median***	$70	$71	$73	$75	$77
		worst	$48	$50	$51	$52	$54
	95th	***median***	$22	$22	$23	$23	$24
		worst	$25	$26	$27	$27	$28
Gasoline	**20th**	***median***	$200	$205	$211	$216	$222
		worst	$200	$205	$211	$216	$221
	50th	***median***	$41	$42	$43	$44	$45
		worst	$41	$42	$43	$44	$45
	95th	***median***	$11	$11	$11	$12	$12
		worst	$12	$12	$13	$13	$13
Heavy Fuel Oil	**20th**	***median***	$465	$476	$489	$501	$514
		worst	$557	$571	$586	$600	$616
	50th	***median***	$351	$360	$369	$378	$388
		worst	$505	$518	$532	$545	$559
	95th	***median***	$190	$195	$200	$205	$211
		worst	$298	$306	$314	$321	$330
Crude	**20th**	***median***	$295	$303	$311	$319	$327
		worst	$360	$369	$379	$388	$398
	50th	***median***	$109	$112	$115	$118	$121
		worst	$139	$143	$147	$150	$154
	95th	***median***	$61	$62	$64	$65	$67
		worst	$77	$79	$81	$83	$85

[1]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Total Estimated Per-Gallon Response Costs For Oil Spills in San Francisco Bay With Primary Mechanical Recovery Operations (Including Shoreline Cleanup)							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1]**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$277	$284	$291	$299	$306
		worst	$326	$335	$343	$352	$361
	50th	***median***	$79	$81	$83	$85	$87
		worst	$55	$56	$58	$59	$61
	95th	***median***	$24	$25	$26	$26	$27
		worst	$29	$30	$30	$31	$32
Gasoline	**20th**	***median***	$227	$233	$239	$245	$251
		worst	$227	$233	$239	$245	$251
	50th	***median***	$46	$48	$49	$50	$51
		worst	$46	$48	$49	$50	$51
	95th	***median***	$12	$12	$13	$13	$13
		worst	$14	$14	$14	$15	$15
Heavy Fuel Oil	**20th**	***median***	$527	$541	$554	$569	$583
		worst	$631	$649	$664	$681	$698
	50th	***median***	$398	$409	$418	$430	$440
		worst	$573	$589	$602	$619	$634
	95th	***median***	$216	$222	$227	$233	$239
		worst	$338	$347	$355	$365	$374
Crude	**20th**	***median***	$335	$344	$352	$362	$371
		worst	$409	$420	$429	$441	$452
	50th	***median***	$124	$127	$130	$134	$137
		worst	$158	$163	$166	$171	$175
	95th	***median***	$69	$71	$72	$74	$76
		worst	$87	$89	$91	$94	$96
[1]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.							

Total Estimated Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Lower Dispersant Efficiency							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percent -ile**	**Shoreline Impact[1,2]**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	***median***	$10,453,000	$10,714,000	$10,997,000	$11,268,000	$11,561,00
		worst	$11,761,000	$12,055,000	$12,373,000	$12,678,000	$13,008,00
	50th	***median***	$14,113,000	$14,466,000	$14,847,000	$15,214,000	$15,609,00
		worst	$10,687,000	$10,954,000	$11,243,000	$11,521,000	$11,820,00
	95th	***median***	$19,492,000	$19,979,000	$20,506,000	$21,012,000	$21,558,00
		worst	$22,354,000	$22,913,000	$23,516,000	$24,098,000	$24,724,00
Gasoline	**20th**	***median***	$9,194,000	$9,424,000	$9,672,000	$9,911,000	$10,169,00
		worst	$9,185,000	$9,415,000	$9,663,000	$9,901,000	$10,159,00
	50th	***median***	$9,681,000	$9,923,000	$10,184,000	$10,436,000	$10,707,00
		worst	$9,661,000	$9,903,000	$10,163,000	$10,415,000	$10,685,00
	95th	***median***	$11,645,000	$11,936,000	$12,251,000	$12,553,000	$12,879,00
		worst	$12,619,000	$12,934,000	$13,275,000	$13,603,000	$13,957,00
Heavy Fuel Oil	**20th**	***median***	$7,708,000	$7,901,000	$8,109,000	$8,309,000	$8,525,00
		worst	$9,203,000	$9,433,000	$9,682,000	$9,921,000	$10,179,00
	50th	***median***	$20,187,000	$20,692,000	$21,237,000	$21,762,000	$22,327,00
		worst	$30,216,000	$30,971,000	$31,787,000	$32,573,000	$33,419,00
	95th	***median***	$41,224,000	$42,255,000	$43,368,000	$44,439,000	$45,594,00
		worst	$69,902,000	$71,650,000	$73,537,000	$75,354,000	$77,312,00
Crude	**20th**	***median***	$18,490,000	$18,952,000	$19,451,000	$19,932,000	$20,450,00
		worst	$22,378,000	$22,937,000	$23,542,000	$24,123,000	$24,750,00
	50th	***median***	$31,352,000	$32,136,000	$32,982,000	$33,797,000	$34,675,00
		worst	$42,272,000	$43,329,000	$44,470,000	$45,569,000	$46,753,00
	95th	***median***	$71,345,000	$73,129,000	$75,055,000	$76,910,000	$78,908,00
		worst	$100,169,000	$102,673,000	$105,378,000	$107,982,000	$110,787,00

[1]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use.

[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Total Estimated Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Lower Dispersant Efficiency							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1,2]**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$11,854,000	$12,178,000	$12,460,000	$12,794,000	$13,108,000
		worst	$13,337,000	$13,702,000	$14,019,000	$14,395,000	$14,748,000
	50th	***median***	$16,004,000	$16,442,000	$16,823,000	$17,274,000	$17,698,000
		worst	$12,119,000	$12,450,000	$12,739,000	$13,081,000	$13,401,000
	95th	***median***	$22,104,000	$22,708,000	$23,234,000	$23,858,000	$24,443,000
		worst	$25,349,000	$26,042,000	$26,646,000	$27,361,000	$28,032,000
Gasoline	**20th**	***median***	$10,426,000	$10,711,000	$10,959,000	$11,253,000	$11,529,000
		worst	$10,416,000	$10,701,000	$10,949,000	$11,242,000	$11,518,000
	50th	***median***	$10,978,000	$11,278,000	$11,540,000	$11,850,000	$12,140,000
		worst	$10,956,000	$11,255,000	$11,516,000	$11,825,000	$12,115,000
	95th	***median***	$13,205,000	$13,566,000	$13,881,000	$14,253,000	$14,603,000
		worst	$14,310,000	$14,701,000	$15,042,000	$15,446,000	$15,824,000
Heavy Fuel Oil	**20th**	***median***	$8,741,000	$8,980,000	$9,188,000	$9,435,000	$9,666,000
		worst	$10,436,000	$10,721,000	$10,970,000	$11,264,000	$11,541,000
	50th	***median***	$22,892,000	$23,518,000	$24,063,000	$24,709,000	$25,314,000
		worst	$34,265,000	$35,202,000	$36,017,000	$36,984,000	$37,891,000
	95th	***median***	$46,748,000	$48,026,000	$49,139,000	$50,458,000	$51,695,000
		worst	$79,269,000	$81,436,000	$83,323,000	$85,560,000	$87,657,000
Crude	**20th**	***median***	$20,968,000	$21,541,000	$22,040,000	$22,632,000	$23,186,000
		worst	$25,377,000	$26,070,000	$26,675,000	$27,391,000	$28,062,000
	50th	***median***	$35,553,000	$36,525,000	$37,372,000	$38,375,000	$39,315,000
		worst	$47,936,000	$49,247,000	$50,388,000	$51,741,000	$53,009,000
	95th	***median***	$80,905,000	$83,117,000	$85,043,000	$87,326,000	$89,467,000
		worst	$113,592,000	$116,697,000	$119,401,000	$122,607,000	$125,612,000
[1]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use. [2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.							

Total Estimated Per-Gallon Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Lower Dispersant Efficiency							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1,2]**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	***median***	$209	$214	$220	$225	$231
		worst	$235	$241	$247	$254	$260
	50th	***median***	$52	$54	$55	$56	$58
		worst	$40	$41	$42	$43	$44
	95th	***median***	$16	$16	$16	$17	$17
		worst	$18	$18	$19	$19	$20
Gasoline	**20th**	***median***	$184	$188	$193	$198	$203
		worst	$184	$188	$193	$198	$203
	50th	***median***	$36	$37	$38	$39	$40
		worst	$36	$37	$38	$39	$40
	95th	***median***	$9	$10	$10	$10	$10
		worst	$10	$10	$11	$11	$11
Heavy Fuel Oil	**20th**	***median***	$308	$316	$324	$332	$341
		worst	$368	$377	$387	$397	$407
	50th	***median***	$202	$207	$212	$218	$223
		worst	$302	$310	$318	$326	$334
	95th	***median***	$101	$103	$106	$108	$111
		worst	$170	$175	$179	$184	$189
Crude	**20th**	***median***	$185	$190	$195	$199	$205
		worst	$224	$229	$235	$241	$248
	50th	***median***	$52	$54	$55	$56	$58
		worst	$70	$72	$74	$76	$78
	95th	***median***	$24	$24	$25	$26	$26
		worst	$33	$34	$35	$36	$37
[1]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use. [2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.							

Total Estimated Per-Gallon Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Lower Dispersant Efficiency							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1,2]**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$237	$244	$249	$256	$262
		worst	$267	$274	$280	$288	$295
	50th	***median***	$59	$61	$62	$64	$66
		worst	$45	$46	$47	$48	$50
	95th	***median***	$18	$18	$19	$19	$20
		worst	$20	$21	$21	$22	$22
Gasoline	**20th**	***median***	$209	$214	$219	$225	$231
		worst	$208	$214	$219	$225	$230
	50th	***median***	$41	$42	$43	$44	$45
		worst	$41	$42	$43	$44	$45
	95th	***median***	$11	$11	$11	$11	$12
		worst	$11	$12	$12	$12	$13
Heavy Fuel Oil	**20th**	***median***	$350	$359	$368	$377	$387
		worst	$417	$429	$439	$451	$462
	50th	***median***	$229	$235	$241	$247	$253
		worst	$343	$352	$360	$370	$379
	95th	***median***	$114	$117	$120	$123	$126
		worst	$193	$199	$203	$209	$214
Crude	**20th**	***median***	$210	$215	$220	$226	$232
		worst	$254	$261	$267	$274	$281
	50th	***median***	$59	$61	$62	$64	$66
		worst	$80	$82	$84	$86	$88
	95th	***median***	$27	$28	$28	$29	$30
		worst	$38	$39	$40	$41	$42
[1]Assumes 35% reduction for HFO and 40% for other oils in shoreline oiling with dispersant use. [2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.							

Total Estimated Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Higher Dispersant Efficiency							
Scenario			Total Projected Response Costs				
Oil Type	Percentile	Shoreline Impact[1,2]	2001	2002	2003	2004	2005
Diesel	20th	*median*	$9,608,000	$9,848,000	$10,108,000	$10,357,000	$10,626,000
		worst	$10,044,000	$10,295,000	$10,566,000	$10,827,000	$11,109,000
	50th	*median*	$11,122,000	$11,400,000	$11,700,000	$11,990,000	$12,301,000
		worst	$9,980,000	$10,230,000	$10,499,000	$10,758,000	$11,038,000
	95th	*median*	$14,539,000	$14,902,000	$15,295,000	$15,673,000	$16,080,000
		worst	$15,493,000	$15,880,000	$16,299,000	$16,701,000	$17,135,000
Gasoline	20th	*median*	$9,183,000	$9,413,000	$9,661,000	$9,899,000	$10,156,000
		worst	$9,180,000	$9,410,000	$9,657,000	$9,896,000	$10,153,000
	50th	*median*	$9,600,000	$9,840,000	$10,099,000	$10,349,000	$10,618,000
		worst	$9,593,000	$9,833,000	$10,092,000	$10,341,000	$10,610,000
	95th	*median*	$11,427,000	$11,713,000	$12,021,000	$12,318,000	$12,638,000
		worst	$11,752,000	$12,046,000	$12,363,000	$12,669,000	$12,998,000
Heavy Fuel Oil	20th	*median*	$6,395,000	$6,555,000	$6,728,000	$6,894,000	$7,073,000
		worst	$7,085,000	$7,262,000	$7,453,000	$7,638,000	$7,836,000
	50th	*median*	$12,385,000	$12,695,000	$13,029,000	$13,351,000	$13,698,000
		worst	$17,014,000	$17,439,000	$17,899,000	$18,341,000	$18,817,000
	95th	*median*	$22,544,000	$23,108,000	$23,716,000	$24,302,000	$24,934,000
		worst	$35,780,000	$36,675,000	$37,641,000	$38,571,000	$39,573,000
Crude	20th	*median*	$14,606,000	$14,971,000	$15,366,000	$15,745,000	$16,154,000
		worst	$15,902,000	$16,300,000	$16,729,000	$17,142,000	$17,588,000
	50th	*median*	$19,804,000	$20,299,000	$20,834,000	$21,349,000	$21,903,000
		worst	$23,444,000	$24,030,000	$24,663,000	$25,273,000	$25,929,000
	95th	*median*	$37,697,000	$38,639,000	$39,657,000	$40,637,000	$41,693,000
		worst	$47,305,000	$48,488,000	$49,765,000	$50,995,000	$52,319,000

[1]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use.
[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Total Estimated Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Higher Dispersant Efficiency							
Scenario			Total Projected Response Costs				
Oil Type	Percentile	Shoreline Impact[1,2]	2006	2007	2008	2009	2010
Diesel	20th	*median*	$10,895,000	$11,193,000	$11,453,000	$11,760,000	$12,048,000
		worst	$11,390,000	$11,701,000	$11,972,000	$12,294,000	$12,595,000
	50th	*median*	$12,612,000	$12,957,000	$13,257,000	$13,613,000	$13,947,000
		worst	$11,317,000	$11,627,000	$11,896,000	$12,216,000	$12,515,000
	95th	*median*	$16,487,000	$16,938,000	$17,330,000	$17,796,000	$18,232,000
		worst	$17,569,000	$18,049,000	$18,468,000	$18,963,000	$19,428,000
Gasoline	20th	*median*	$10,414,000	$10,698,000	$10,946,000	$11,240,000	$11,515,000
		worst	$10,410,000	$10,695,000	$10,943,000	$11,236,000	$11,512,000
	50th	*median*	$10,886,000	$11,184,000	$11,443,000	$11,750,000	$12,038,000
		worst	$10,878,000	$11,176,000	$11,435,000	$11,742,000	$12,030,000
	95th	*median*	$12,958,000	$13,312,000	$13,621,000	$13,987,000	$14,329,000
		worst	$13,327,000	$13,691,000	$14,008,000	$14,384,000	$14,737,000
Heavy Fuel Oil	20th	*median*	$7,252,000	$7,450,000	$7,623,000	$7,827,000	$8,019,000
		worst	$8,034,000	$8,254,000	$8,445,000	$8,672,000	$8,885,000
	50th	*median*	$14,045,000	$14,429,000	$14,763,000	$15,159,000	$15,531,000
		worst	$19,294,000	$19,821,000	$20,281,000	$20,825,000	$21,336,000
	95th	*median*	$25,565,000	$26,264,000	$26,872,000	$27,594,000	$28,270,000
		worst	$40,575,000	$41,684,000	$42,650,000	$43,795,000	$44,868,000
Crude	20th	*median*	$16,563,000	$17,016,000	$17,410,000	$17,878,000	$18,316,000
		worst	$18,033,000	$18,526,000	$18,955,000	$19,464,000	$19,941,000
	50th	*median*	$22,458,000	$23,072,000	$23,606,000	$24,240,000	$24,834,000
		worst	$26,585,000	$27,312,000	$27,945,000	$28,695,000	$29,399,000
	95th	*median*	$42,748,000	$43,917,000	$44,935,000	$46,141,000	$47,272,000
		worst	$53,644,000	$55,110,000	$56,388,000	$57,901,000	$59,320,000
[1]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use. [2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.							

Total Estimated Per-Gallon Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Higher Dispersant Efficiency							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1,2]**	**2001**	**2002**	**2003**	**2004**	**2005**
Diesel	**20th**	***median***	$192	$197	$202	$207	$213
		worst	$201	$206	$211	$217	$222
	50th	***median***	$41	$42	$43	$44	$46
		worst	$37	$38	$39	$40	$41
	95th	***median***	$12	$12	$12	$13	$13
		worst	$12	$13	$13	$13	$14
Gasoline	**20th**	***median***	$184	$188	$193	$198	$203
		worst	$184	$188	$193	$198	$203
	50th	***median***	$36	$36	$37	$38	$39
		worst	$36	$36	$37	$38	$39
	95th	***median***	$9	$9	$10	$10	$10
		worst	$9	$10	$10	$10	$10
Heavy Fuel Oil	**20th**	***median***	$256	$262	$269	$276	$283
		worst	$283	$290	$298	$306	$313
	50th	***median***	$124	$127	$130	$134	$137
		worst	$170	$174	$179	$183	$188
	95th	***median***	$55	$56	$58	$59	$61
		worst	$87	$89	$92	$94	$97
Crude	**20th**	***median***	$146	$150	$154	$157	$162
		worst	$159	$163	$167	$171	$176
	50th	***median***	$33	$34	$35	$36	$37
		worst	$39	$40	$41	$42	$43
	95th	***median***	$13	$13	$13	$14	$14
		worst	$16	$16	$17	$17	$17

[1]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use.
[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

Total Estimated Per-Gallon Response Costs For Oil Spills in San Francisco Bay With Primary Dispersant Operations (Including Shoreline Cleanup) Higher Dispersant Efficiency							
Scenario			**Total Projected Response Costs**				
Oil Type	**Percentile**	**Shoreline Impact[1,2]**	**2006**	**2007**	**2008**	**2009**	**2010**
Diesel	**20th**	***median***	$218	$224	$229	$235	$241
		worst	$228	$234	$239	$246	$252
	50th	***median***	$47	$48	$49	$50	$52
		worst	$42	$43	$44	$45	$46
	95th	***median***	$13	$14	$14	$14	$15
		worst	$14	$14	$15	$15	$16
Gasoline	**20th**	***median***	$208	$214	$219	$225	$230
		worst	$208	$214	$219	$225	$230
	50th	***median***	$40	$41	$42	$44	$45
		worst	$40	$41	$42	$43	$45
	95th	***median***	$10	$11	$11	$11	$11
		worst	$11	$11	$11	$12	$12
Heavy Fuel Oil	**20th**	***median***	$290	$298	$305	$313	$321
		worst	$321	$330	$338	$347	$355
	50th	***median***	$140	$144	$148	$152	$155
		worst	$193	$198	$203	$208	$213
	95th	***median***	$62	$64	$66	$67	$69
		worst	$99	$102	$104	$107	$109
Crude	**20th**	***median***	$166	$170	$174	$179	$183
		worst	$180	$185	$190	$195	$199
	50th	***median***	$37	$38	$39	$40	$41
		worst	$44	$46	$47	$48	$49
	95th	***median***	$14	$15	$15	$15	$16
		worst	$18	$18	$19	$19	$20

[1]Assumes 70% reduction for HFO and 80% for other oils in shoreline oiling with dispersant use.
[2]Shoreline costs for median and worst water column-impacted runs for diesel and gasoline and median and worst shoreline cost runs for HFO and crude based on SIMAP modeling runs.

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